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Contract Report

Selection of a New Inland Oil Skimmer for the Navy

ABSTRACT The Crowley/Alden A-4 has been selected as the next generation of small inland oil skimmers to be procured by NAVFAC for the Navy. This report details the research performed by NCEL in order to identify the required and actual capabilities of this skimmer to determine if this oil skimmer is the best candidate for future Navy use.

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FOREWORD

This report describes the Naval Civil Engineering Laboratory (NCEL) research program of oil spill equipment and oil spill cleanup techniques that resulted in NAVFAC procuring the new Navy small inland oil skimmer, the Crowley/Alden A-4.

EXECUTIVE SUMMARY

A new type of inland oil skimmer, the Crowley/Alden A-4, has been procured and tested for final acceptance by the Navy. A program to identify a new inland oil skimmer was initiated because the existing small (SLURP) and medium (DIP 1002) oil skimmers were not being utilized by the activities. The low utilization of these skimmers was attributed to poor operational efficiency under typical Navy oil spill conditions. The SLURP skimmer is ineffective in waves and labor intensive. The DIP 1002 skimmer is large, heavy, and complex to set up, operate, and maintain.

The performance criteria used in the selection of the new inland oil skimmer evolved from the criteria developed in 1972 as part of the evaluation process that resulted in the procurement of the SLURP and DIP 1002 oil skimmers. The performance criteria are defined in five Go/No-Go criteria that must be satisfied for the oil skimmer to be considered, and 10 ranking criteria with the effectiveness ratio for consideration set at 75 out of a possible 100 points.

Once the candidate systems were identified, manufacturers and suppliers of these systems were asked to submit cost proposals for providing the skimmers to the Navy. The best technical proposal with the lowest bid was accepted.

The Crowley/Alden A-4 was selected as the best skimmer for meeting Navy needs. It was subjected to functional tests at the manufacturer's facilities to ensure that all the components of the system were operating as specified. Then, the Alden A-4 was subjected to first article testing at the Environmental Protection Agency's (EPA's) Oil and Hazardous Material Simulated Environmental Test Tank (OHMSETT) facility in Leonardo, NJ to prove Navy requirements (as identified in the performance criteria and the manufacturer's proposal) were met. Overall the skimmer met or exceeded the performance characteristics required for inner harbor use (Ref 1).

The final step in the acceptance study of the new inland oil skimmer consisted of field testing the skimmer. Thirty skimmers were procured and supplied to selected activities for use and evaluation. Material and packaging modifications were requested by the activities. Responses on the usefulness of the skimmer in the recovery of oil spills were positive.

It was recommended that the Navy proceed with the procurement of the remainder of the skimmer units during FY88 and FY89, after implementing approved modifications.

CONTENTS

INTRODUCTION

The Background section of this report reviews the oil spill recovery technology based on the studies performed at the Naval Civil Engineering Laboratory (NCEL) in the early 1970s. The technical approach section discusses the work performed to develop a new set of selection criteria for the new small inland oil skimmer. The section on results describes the performance of the new inland oil skimmer under laboratory test condition and during field tests.

BACKGROUND

The general characteristics of oil spills will be discussed followed by a discussion on the characteristics particular to Navy oil spills. The research performed in the mid 1970s for the procurement of the first oil recovery equipment will be discussed before reviewing the performance of the old small and medium oil skimmers.

Definition of an Oil Spill

The Naval Facilities Engineering Command (NAVFAC) publication on Oil Spill Control for Inland Waters and Harbors (Ref 2) defines an oil spill as "a discharge (including but not limited to any spilling, leaking, pumping, pouring, emitting, emptying or dumping) of any oil of any kind, intentional or accidental, into the navigable waters of the United States and adjoining shorelines or into the contiguous zone and the high seas where a threat to the United States waters, shoreface, or shelf bottom exist."

Harmful quantities are defined in the Accidental Oil Spill Report (Ref 3) as "spills that violate applicable water quality standards, cause a sheen or discoloration of the water surface, or cause a sludge or emulsion to be deposited beneath the surface of the water,"

Oil Spill Characteristics

Understanding the general characteristics of an oil spill can help in the adoption of the correct procedure to recover the spill. The amount of oil that needs to be recovered and the correct placement of containment systems can be obtained from a visual inspection of the spill.

The Table 1 gives an indication of the quantity of oil in a spill according to visual signs. Figure 1 gives typical spill distribution patterns under different conditions. The spill distribution patterns can be used to provide guidance for the best recovery procedure.

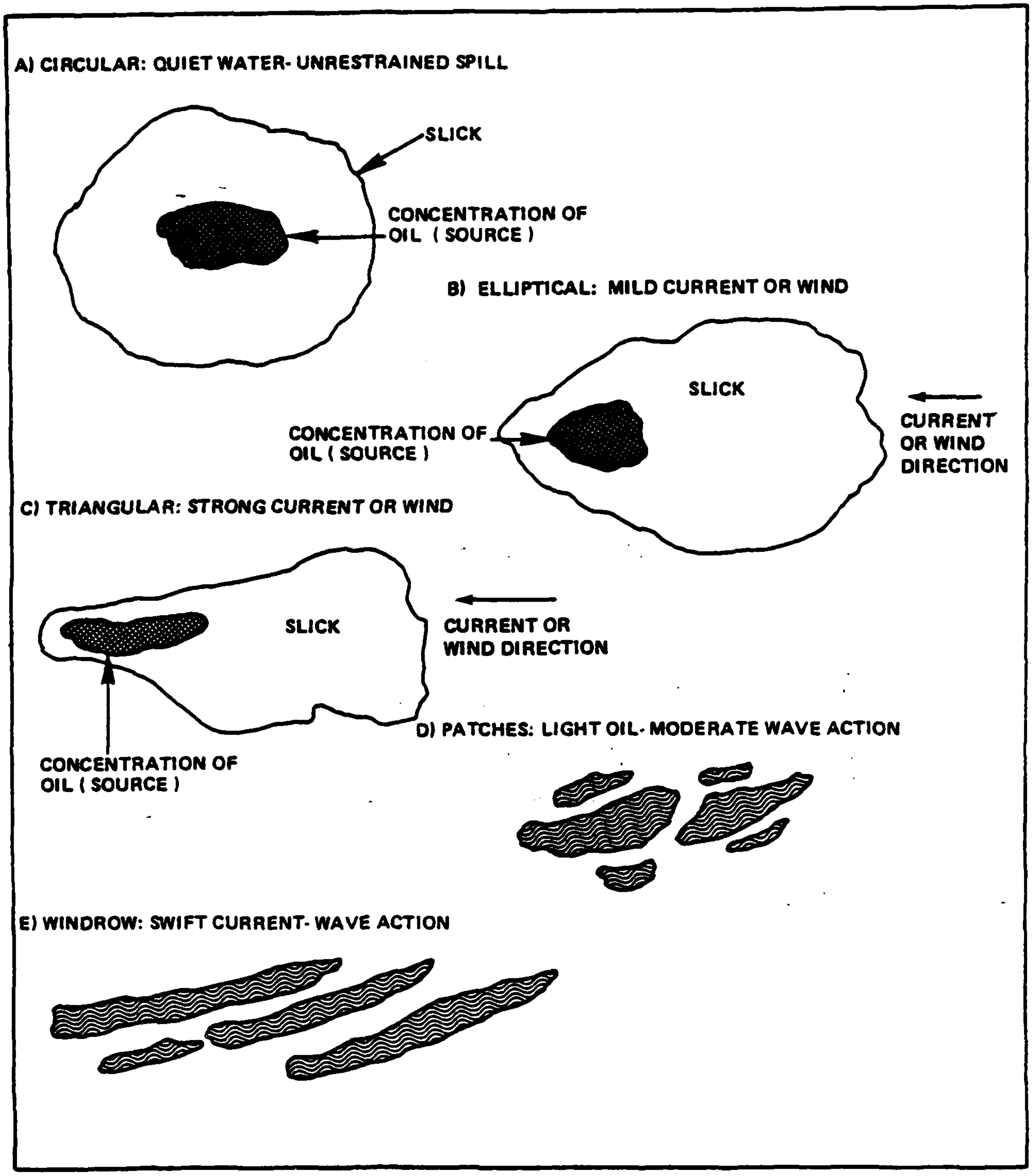

Figure 1. Typical spill distribution patterns (NAVFAC) Manual P-908.

Table 1. Oil Slick Appearance as Related to Quantity[a]

Appearance of Slick	Quantity (gal/sq mile)
Barely discernible	25
Silvery sheen	50
Faint color	100
Bright color bands	200
Dull brown	666
Dark brown	1,332

[a]Table obtained from NAVFAC Manual P-908 (Ref 2).

Characteristics of Navy Oil in Spills

The nature of Naval Operations lends certain characteristics to the oil spills that need to be recovered by the Navy. These characteristics can be exploited to yield an oil skimmer that is more suitable to Navy operations than a general oil skimmer.

Records of the spills by the Navy have been available since the initiation of the reporting of oil spills as required by the Chief of Naval Operations in OPNAVNOTE 6240 of November 1971. During the NCEL study in the 1970s, detailed records to determine characteristics of Navy spills were not available. The assumptions made at the stage to identify parameters for the selection of the oil skimmers were that the spills could be categorized into harbor spills of approximately 500 gallons in size and open water spills of approximately 10,000 gallons in size (Ref 4). From the tables in Appendix A, obtained from the Accidental Oil Spills Annual Reports (Ref 3), it can be seen that these values can be refined.

Summaries from the Accidental Oil Spills Annual Reports from 1982 to 1986 (Ref 3) are included in Appendix A. From these summaries, it can be seen that approximately 80 percent of the spills polluted harbor waters and that approximately 80 percent of the spills involved quantities of less than 200 gallons. Table 2 contains information on Navy oil spills.

Table 2. Navy Oil Spills - Location, Type, and Volume

Year	Percent of Total Occurrences						
	Spills in Port	Ashore Water Pollut.	DFM	JP-4 & 5	Volume Range (gallons)		
					0-50	51-00	101-200
1982	88.0	----	53.0	9.0	69.0	12.0	6.0
1983	84.0	----	54.0	6.0	63.0	14.0	7.0
1984	81.1	11.5	49.4	13.7	58.5	15.8	7.0
1984	74.0	11.0		16.3	60.0	12.0	9.0
FY86	75.9	5.6		15.1	60.0	13.5	8.0

Approximately 60 percent of the oils that were spilled by Naval Activities are Jet Fuel (JP-5) and Diesel Fuel Marine (DFM). The characteristics of these two types of fuels are contained in Table 3.

Table 3. DFM and JP-5 Characteristics[a]

Characteristic	DFM[b]	JP-5[c]
Flash point (°C)	60	60
Maximum ash content (%)	0.005	--
Gravity (°API min/max)	35	36.0(48.0)
Viscosity (centistokes) max	1.8-4.5 (100°F)	16.5 (-30°F)

[a]Obtained from NCEL Technical Memorandum 54-84-08 (Ref 5).
[b]MIL SPEC MIL-F-16884G Amendment-1, 22 Mar 1978, fuel oil, diesel, marine.
[c]MIL SPEC MIL-T-5624J, 30 Oct 1973, turbine fuel, aviation, grades JP-4 and JP-5.

EARLIER NCEL SKIMMER RESEARCH

In the early 1970s NCEL was tasked to evaluate commercially available oil skimmers in order to select the most suitable oil spill recovery system for Navy applications. The resulting research effort, continuing through the mid 1970s, evolved into three phases (Ref 6). The research effort was published in a series of technical memoranda and a technical note (Ref 4,5,6,7,8).

The objective of Phase I was to identify and evaluate the best system of commercially available "off-the-shelf" items for cleaning of oil spills in both confined and open spaces. The objective of Phase II was to develop standard performance test procedures pertinent to the EPA OHMSETT testing facility. The aim of the tests at OHMSETT was to improve the performance of oil containment and recovery systems. In addition, utility equipment for use in a harbor was evaluated. Phase III involved cold weather evaluation tests of harbor oil spill cleanup equipment, analytical cost and system effectiveness studies, test and evaluation of new oil spill cleanup equipment and documentation of the entire program.

Subsystems

Unlike the present study, the research in the mid 1970s embraced the complete oil recovery system. The components of the recovery system that were analyzed are as follows:

- Containment subsystem consisting of containment booms.
- Removal subsystem consisting of different types of oil skimmers.
- Storage subsystem consisting of various tanks and bladders.
- Transfer subsystems consisting of different types of pumping equipment.

* Oil water separation subsystem.
* Waste oil disposal subsystem.

Each of these subsystems will now be discussed. The track record of each of the subsystems was based on performance, operation, and maintenance criteria.

Containment Subsystem. The containment subsystem is used primarily to keep the oil spill from spreading. The containment of the oil spill has the additional benefit of controlling the direction of the spill movement (ideally in the direction of the skimmer). The evaluation and tests performed on these systems are discussed in detail in References 4 and 9. The study selected the Aqua Fence and Sea Curtain booms as the most suitable containment subsystems.

Removal Subsystem. The removal subsystem consists of oil skimmer that are based on different technologies and designs. Examples of the different technologies are in Figure 2. These systems were evaluated in detail and discussions of the evaluation procedures are given in References 2,4,7,8,9, and 10.

The study concluded that the DIP 1002 skimmer should be used for spills too large for the SLURP skimmer; and for spills too small or not accessible to the DIP 3001 skimmer, intended for use in open water.

Transfer Subsystems. The different systems that can be used to transfer oil skimmed from the water surface to a higher elevation are pumping, vacuum lift, and friction lift.

The test program on the transfer subsystems was confined to pumping tests. The objective of the pumping tests was to determine the flow rate, power requirements, and transfer hose pressure drop associated with the transfer of an oil-water-debris mixture from a skimmer craft to an oil storage tank. One problem that received attention was the emulsification of the oil in the oil water mixture by certain pumps at different pumping rates.

The Parker double-diaphragm, air-operated pump was judged the best transfer subsystem. It is light, simple to repair and maintain, reliable in the presence of debris, and has a low tendency to emulsify the oil-water mixture.

Storage Subsystem. The purpose of the storage subsystems is the provision of temporary of the skimmed oil-water mixture prior to further separation and disposal. The storage subsystem can either be on the water surface with the skimmer or it can be situated on land (i.e., stationary). In the case of the stationary storage subsystem, the movement of the skimmer is restricted to the length of the piping used for transfer of the recovered oil-water mix to the storage subsystem.

The ease of handling, low weight, and easy access to the filling and discharge ports made the Sea Container Storage Subsystem the preferred choice in the study.

Separator Subsystems. Separators are used to increase the oil concentration of the recovered oil-water mixture. In the initial tests two coalescing-type separators and one parallel plate, laminar flow, gravity separator were tested.

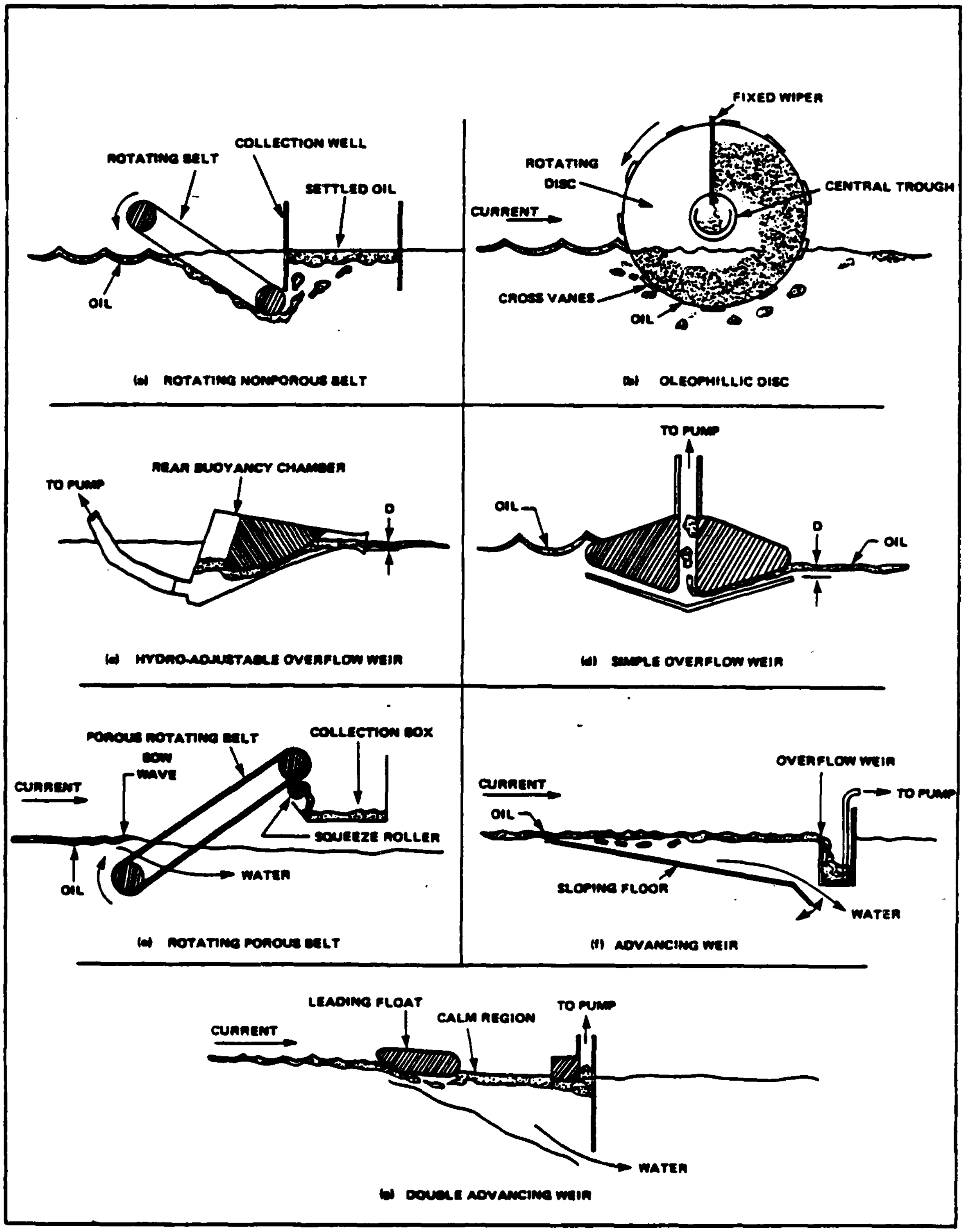

Figure 2. Oil removal subsystem types (Ref 2).

The study concluded that a coalescing and a parallel plate separator would have to be used in series to obtain an acceptable product in the case of oil recovery by the weir skimmers.

Disposal Subsystems. Various methods of disposal of the recovered oil were suggested. These earlier recommendations included using the oil as a fuel in noncritical application such as the cofiring of heating furnaces, disposing of the oil in landfills, or attempting to recover it to such a degree that it can be reused. They recycling of the recovered oil is the preferred solution at present. These recommendations were acceptable at the time they were made but because of the constraints of Resource Conservation and Recovery Act (R-C-R-A), should not be used at the present time without further investigation.

Selection Procedure (Mid 1970s)

The equipment selection procedure was performed in two stages. During the first stage, data were collected from the manufacturers by way of questionnaires (Ref 9) and evaluated to identify subsystem elements for testing. Subsystem elements were selected from the test to be combined into complete oil spill recovery systems for final testing.

The data collected from the manufacturers were evaluated using Equation 1 (Ref 9).

$$E = \sum_{i=i}^{n} R_i W_i \qquad (1)$$

where: E = numerical evaluation value of a given subsystem (Effectiveness Index)
n = number of rating parameters considered
R_i = rating of the ith parameter
W_i = weight of the ith parameter

The values used in weighting the parameters reflect their relative importance to the operating environment. The values used can be obtained from Appendix B.

The rating of each parameter was based on a graphical relationship between numerical scores ranging from 0 to 4 and various ranges of the raw data for a given parameter (Ref 11). The ranges of the raw data for each parameter pertinent to each subsystem can again be obtained from the references (Ref 9). The results from the tests on the removal subsystems are summarized in Table 4.

A rudimentary sensitivity analysis was performed on the influence of the weight assigned to the different parameters. The indications were that a very small change to the effectiveness index resulted from a change of as much as 20 percent to some of the weighting factors.

Since this report is concerned with the selection of a new inland oil skimmer, the remainder of the text will focus attention on the recovery subsystem, and the small and medium oil skimmers selected as a result f the mid 1970s research.

Table 4. Summary of Results from Oil Skimmer Evaluation Mid 1970s Study

Skimmer Description	Total Points Obtained (40 maximum)
Small And Medium	
DIP 1001	21.77
SLURP	21.29
Oil Hawg	17.38
Clean Sweep	15.61
Macro Class 1	14.44
Large	
DIP 3001	15.89
ORS	15.81
Huskey	15.50
Spillmaster	14.94
Macro Class II	14.94

Performance of the Previous Small and Medium Oil Skimmer

The small and medium oil skimmers that were selected for procurement by NAVFAC were the JBF DIP 1001 (for use in the case of medium oil spills), and the SLURP skimmer (to be used for small spills in confined areas). The performance of the skimmers will be discussed following a description of the skimmers.

The SLURP (see Figure 3), the small oil skimmer, is a self-equilibrating, saucer-type, weir skimmer operating on the hydro-adjustable, overflow-weir principle and is intended for stationary applications. The interaction between the weight of the skimmer, including the skimmed oil-water mixture and its buoyancy, causes the skimmer to pitch to a stable equilibrium position. The pitching and the pumping rate adjust the weir to the necessary attitude for the optimum operation. The operation of the SLURP is diagrammed in Figure 4. A typical operating environment for the SLURP is given in Figure 5.

The JBF DIP 1001, the medium oil skimmer, is an inverted belt skimmer operating on the principle of the rotating, nonporous belt. The JBF DIP 1001 skimmer is shown in Figure 6. A diagram showing the system configuration is in Figure 7. As the skimmer moves through the water or as the water flows past the skimmer, the oil is forced to follow the surface of the moving inclined plane to a collection well underneath the skimmer. Buoyant forces cause the oil to surface in the well forcing water out the bottom. As the oil is collected, it may be pumped out of the skimmer into storage containers. The skimmer can be used in either a stationary mode or in an advancing mode.

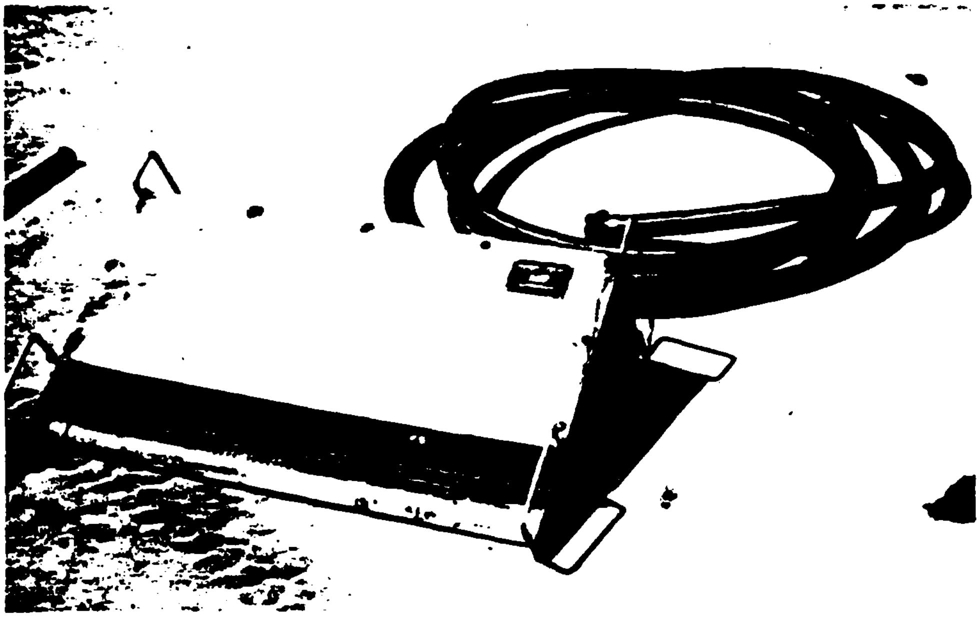

Figure 3. The SLURP skimmer (Ref 8).

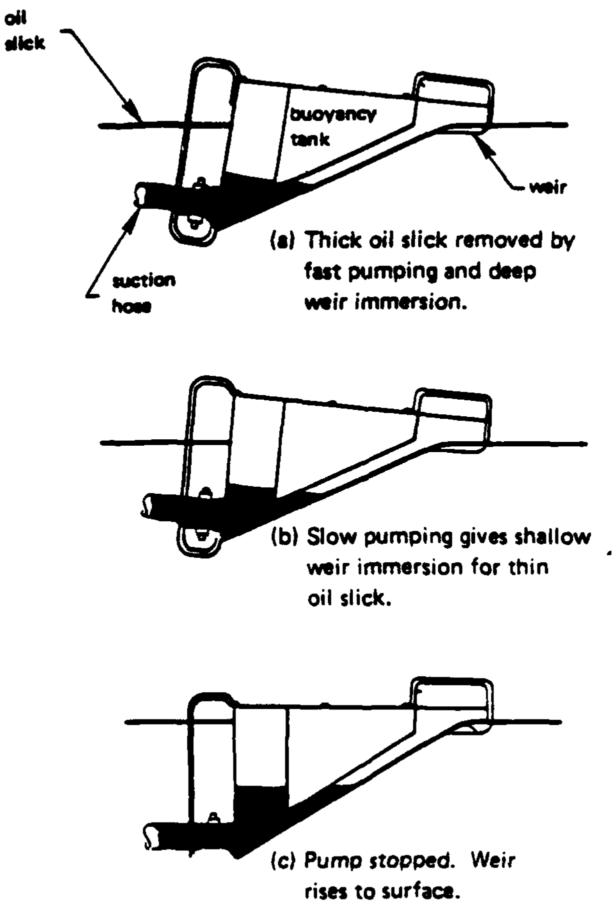

Figure 4. Principle of operation of the SLURP skimmer (Ref 8).

Laboratory Analysis. Laboratory tests were performed on the small and medium oil skimmers that were selected during the evaluation phase. Further tests were performed at EPA's OHMSETT test site on the skimmers selected for procurement as part of Phase II of the mid 1970s study.

The initial laboratory tests were performed at two separate test sites. The testing techniques used in this part of the program varied from device to device but every effort was made to test each device in an environment which best simulated actual filed conditions (Ref 9). The selection of the JBF DIP 1001 and SLURP skimmers for procurement was based on the results of these tests (Ref 9).

Standard performance test procedures were developed at EPA's OHMSETT facility for evaluating the skimmers selected for procurement (Ref 7). The results of the test for the DIP 1001 and the SLURP skimmers are given in Figures 8 through 11.

Additional tests were performed at OHMSETT to determine the optimum belt speed, belt angle, and backplate opening for the JBF DIP 1001 Oil Skimmer. The results showed that the belt was set at the optimum angle (Ref 7). The oil recovery rate as a function of the backplate opening and belt speeds is variable and settings for different operating environments are recommended (Ref 8).

Estimates of cost analyses for different oil spill scenarios were performed to determine the cost effectiveness of the recovery procedure adopted. The results corresponded closely to the filed data obtained from the activities involved in oil spill cleanup operations (Ref 6). The cost effectiveness study indicated that the optimum procedure depends on the spill size and location. A recommendation was proposed for the activities to develop oil spill recovery plans so that the most cost effective methodology could be used for each spill identified (Ref 6).

Additional Tests. Phase III of the oil skimmer study involved a cold weather evaluation test of harbor spill cleanup equipment. The results were inconclusive because during the period the test was scheduled mild weather prevailed and the required information could not be gathered.

The Human Factors Engineering Branch at the Pacific Missile Test Center, Point Mugu, California conducted a study to determine the actual requirements and experience of activities using NAVFAC procured oil spill cleanup equipment and to propose safety requirements deemed necessary (Ref 10). Only minor modifications to the equipment were suggested. It was concluded that safety does not present a major problem.

Operational Results of the Old Skimmers. Problems with the small oil skimmer, the slurp include the availability of spare parts, low oil recovery efficiencies, and labor intensive manual control to effectively operate and keep oil recovery rates at an acceptable level. The small skimmer is also very inefficient in waves. Problems associated with the equipment include a storage bag and separator that are constructed of a material that is easily damaged, and a storage bag that is difficult to empty.

Spare parts for the medium oil skimmer are difficult to obtain causing a maintenance burden on the user activity. Maintenance problems include a weak wand/skimmer coupling, excessive amounts of debris in the storage reservoir, and leveling jacks that jam. The unit is too large

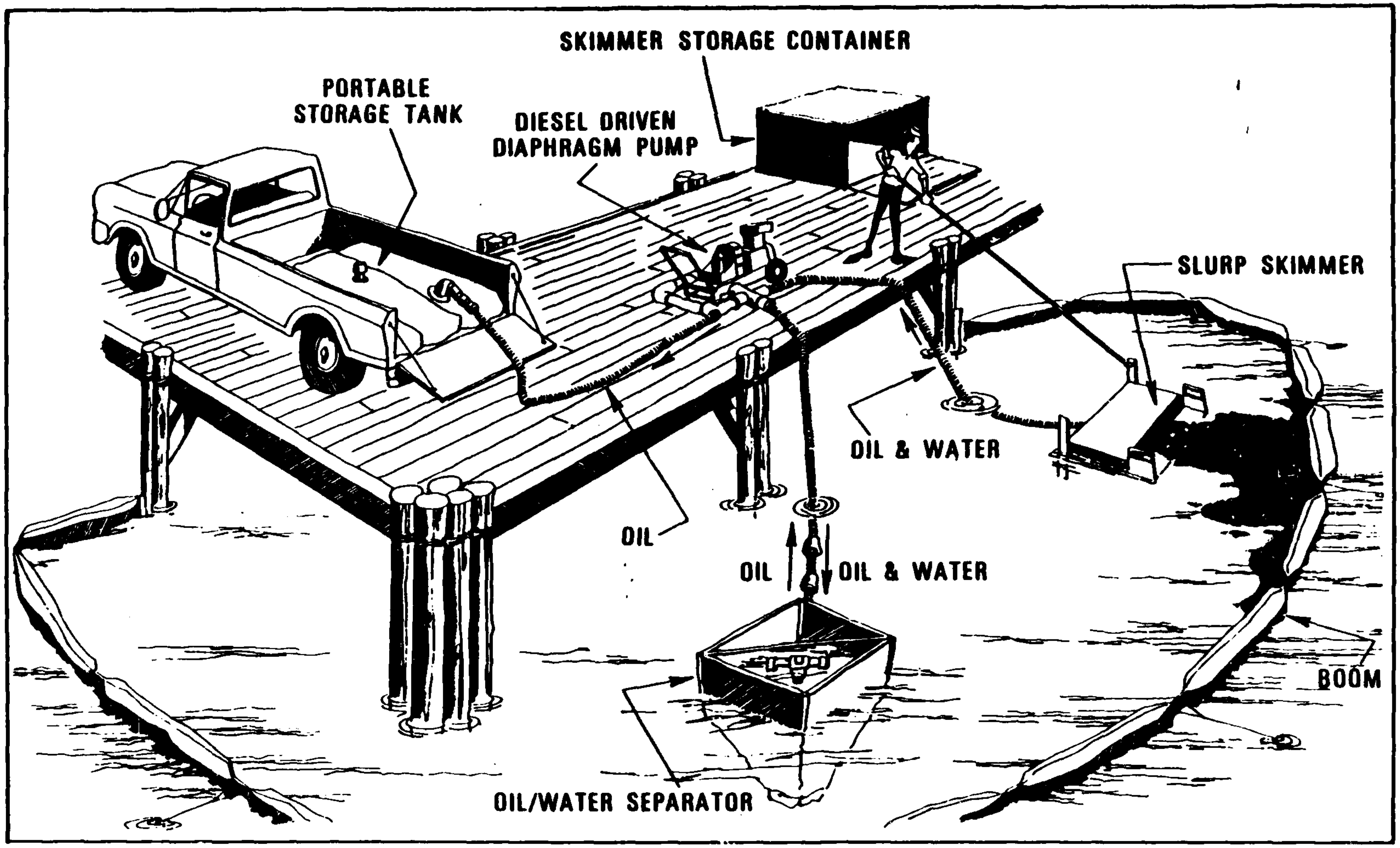

Figure 5. Operating environment for the SLURP skimmer (Ref 8).

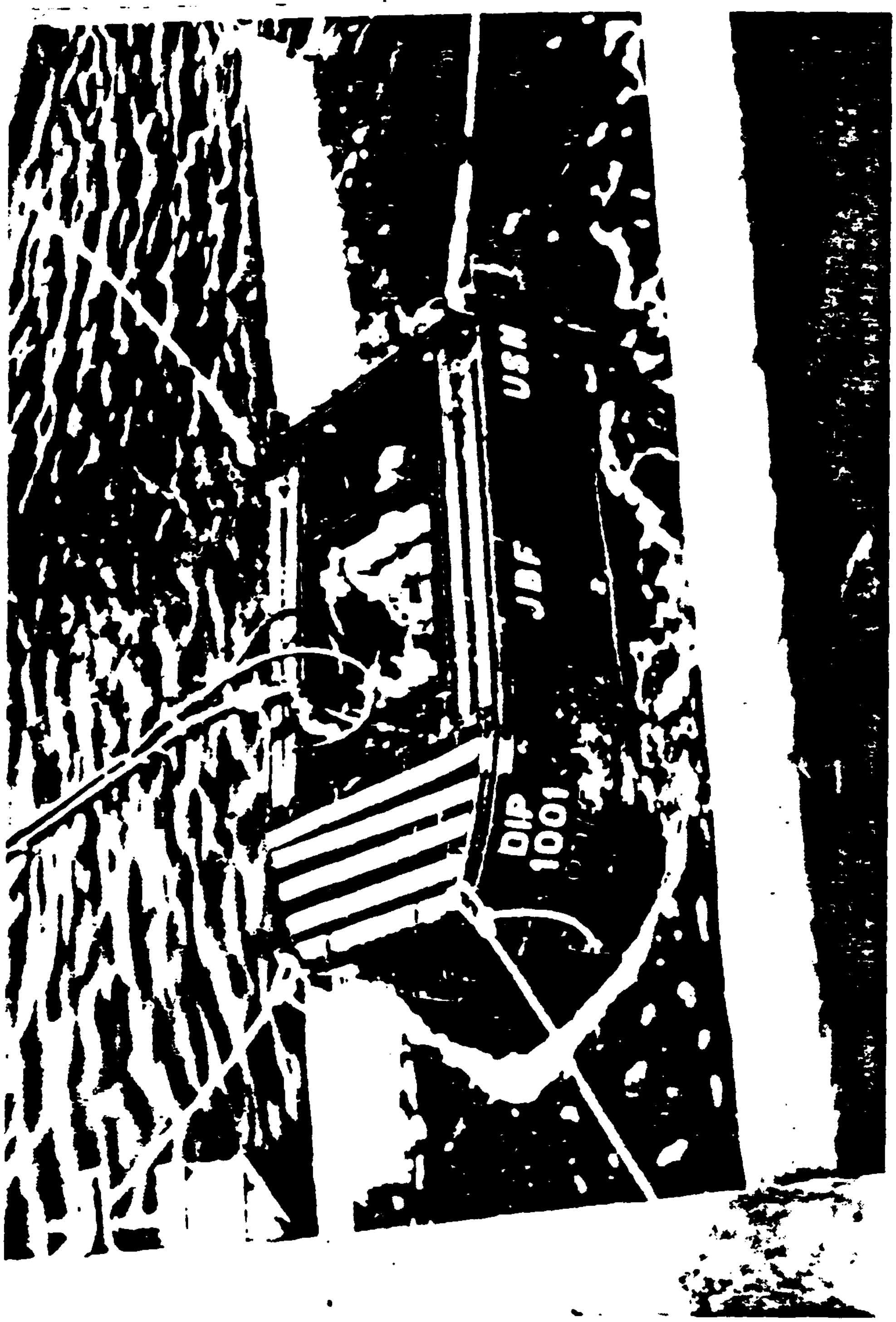

Figure 6. The JBF DIP 1001 skimmer (Ref 8).

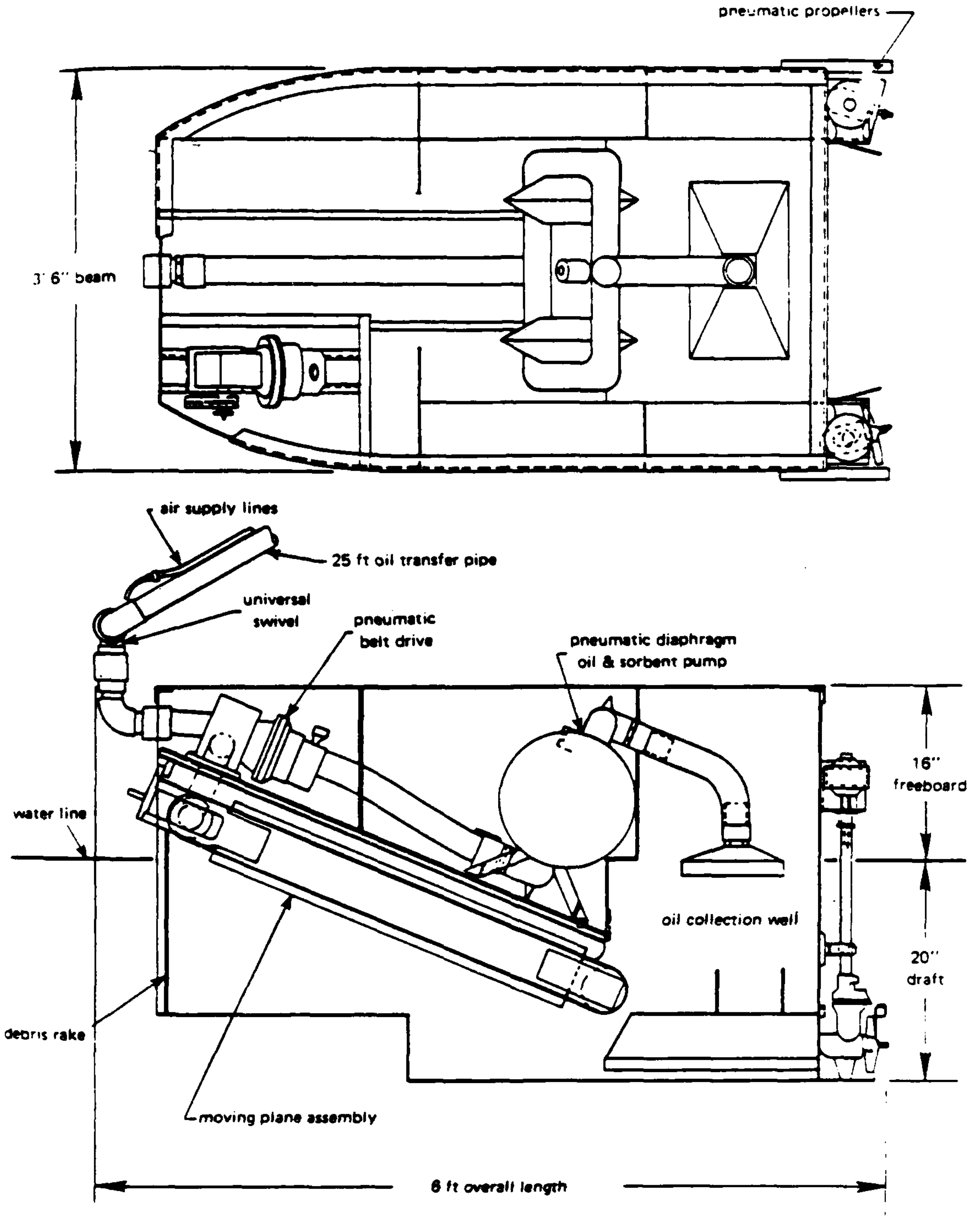

Figure 7. Diagrammatic layout of the JBF DIP 1001 skimmer (Ref 9).

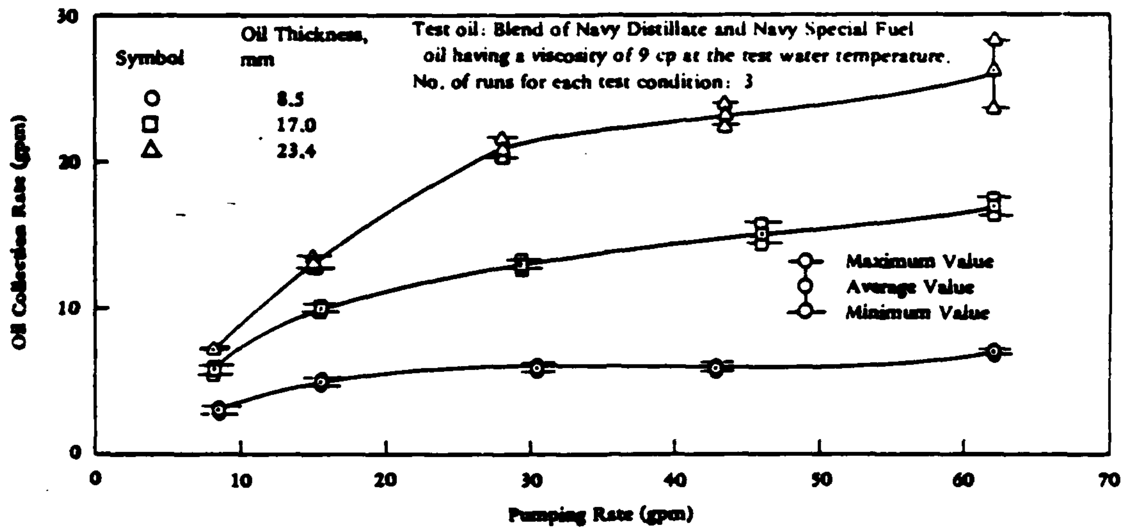

Figure 8. SLURP skimmer, oil collection rate (Ref 7).

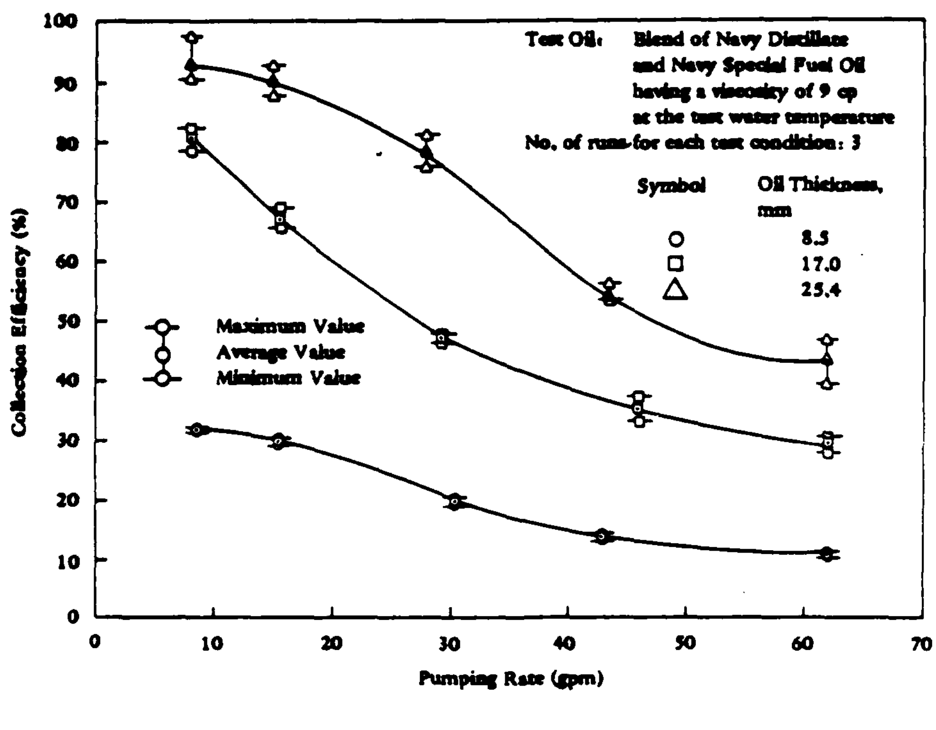

Figure 9. SLURP skimmer, oil collection efficiency (Ref 7).

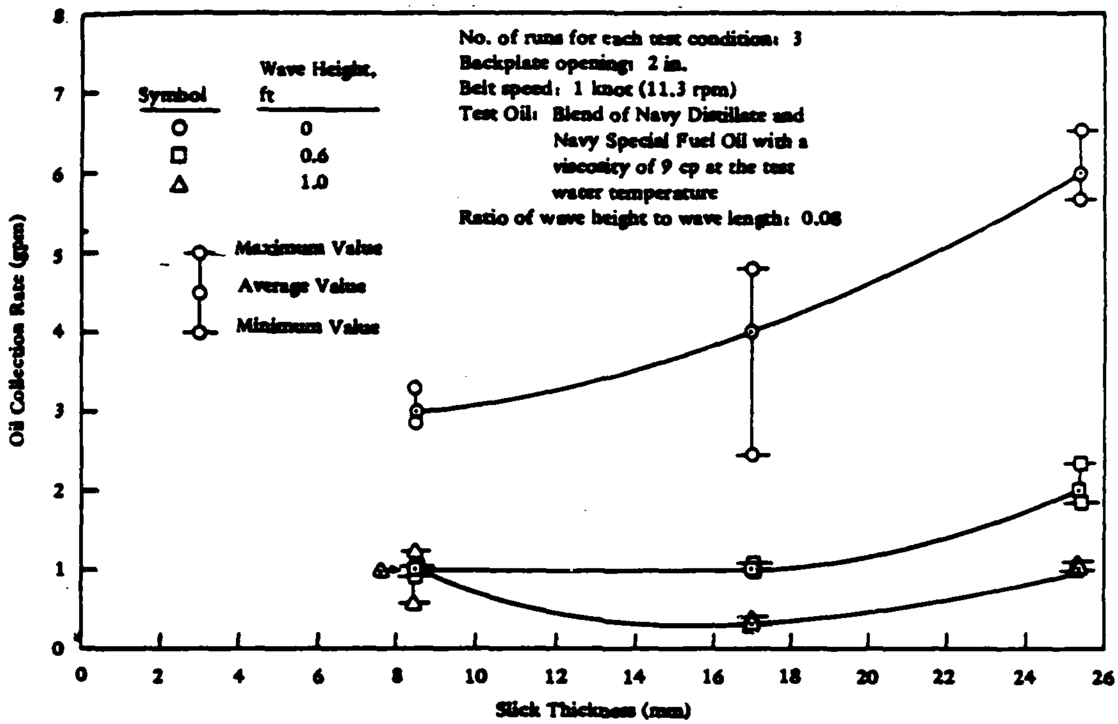

Figure 10. DIP 1001 skimmer, oil collection rate (Ref 7).

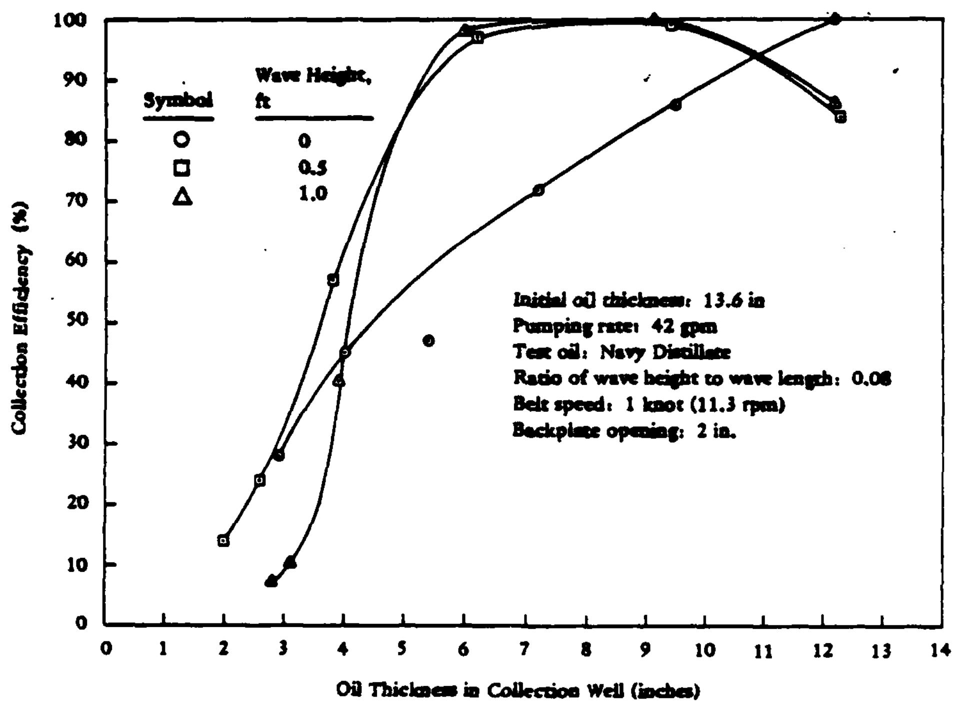

Figure 11. DIP 1001 skimmer, oil collection efficiency (Ref 7).

for use near the shore and between ships and piers, and too heavy for use in marshy areas. Access to shore areas is restricted by the 1-ton van required for transport. The skimmer is labor intensive to operate, requiring a minimum of two men full time to operate.

CURRENT NCEL RESEARCH

Since 1975, the use of the small and medium oil skimmers by the Navy, has reduced dramatically. NCEL was tasked by NAVFAC to develop performance criteria for the selection of a new inland oil skimmer (Ref 5) and to proceed with the procurement of the selected oil skimmer for the Navy.

Development of Selection Criteria

The selection of the new small oil skimmer for the Navy was performed using five Go/No-Go and 10 ranking selection criteria. The selection criteria used in the mid 1970s oil skimmer evaluation program were modified and expanded to accommodate current Navy needs. Site visits, interviews with command and equipment-user personnel, and studies of skimmer usage and Navy oil spills were used to identify current Navy needs.

The data required for the evaluation of the technical proposals were obtained from different manufacturers and suppliers by means of a questionnaire. The manufacturers and suppliers that submitted a technical proposal that satisfied the selected criteria were issued an Invitation for Bid. The technical proposal with the lowest cost was accepted.

Outline of Testing Procedures

The selected oil skimmer system was subjected to a set of seven functional tests to confirm that the skimmer was mechanically complete and met the physical skimmer requirements. The functional tests were performed at the manufacturer's facilities. The first article tests, designed to test the skimmer performance characteristics as defined by the selection criteria, were conducted at the EPA's OHMSETT facilities.

Thirty skimmer units were procured and subjected to field evaluation at preselected activities. A standard skimmer usage report form was prepared to provide data for performing reliability, availability and maintainability (RAM) calculations. The RAM results were to be checked against industry standards. Recommendations on methods for improving skimmer performance were obtained from the Naval activities.

RESULTS

Selection Criteria

NCEL identified the following as the major Navy needs that must be satisfied by a small oil skimmer system. The skimmer needs to operate effectively under typical environmental conditions in Navy harbor and

shore areas. The skimmer also needs to more effectively utilize Navy cost and manpower resources.

A new set of selection criteria was developed to aid in quantifying the selection of the new inland oil skimmer. The complete set of selection criteria is given in Table 5. The selection criteria were grouped under two main sections. The sections consist of five Go/No-Go criteria and ten Ranking criteria. Each selection criteria will be discussed under the section heading.

Table 5. New Skimmer Selection Criteria (Ref 2).

Weight Factor	Rank	Criteria	Standard
		Go/No Go	
		Type of oil	DFM and JP-5
		Self-sufficient system	Must contain everything needed to operate
		Operating manpower	Operator not required for skimmer operation for periods of up to 4 hours; can be in area
		Type of transfer pump	Use a positive displacement pump
		Maximum draft	1 foot
		Ranking	
15	1	Recovery rate	120 gal of oil per hour Utility Factor: <40 gal/hr = 0 40-79 gal/hr = 0.33 80-120 gal/hr = 0.66 >120 gal/hr = 1.00
15	2	Deployment time	20 min from reaching spill site to being operational Utility Factor: >60 min = 0 40-60 min = 0.25 31-39 min = 0.50 21-30 min = 0.75 20 min or less = 1.00

(continued)

Table 5. New Skimmer Selection Criteria (Ref 2).

Weight Factor	Rank	Criteria	Standard
13	3	Wave impact	Unit achieves design performance in wave 1 ft in height with harbor chop Utility Factor: Calm conditions = 0 0-3 in. = 0.25 4-7 in. = 0.50 8-11 in. = 0.75 >12 in. = 1.00
11	4	Proven equipment	Manufacturer's claims validated by actual spill use and by credible test laboratory Unvalidated manufacturer claim = 0 Validated by user (actual spill) = 0.50 Validated by credible test lab = 1.00
10	5	Oil recovery efficiency	80% of mixture is oil at the time of recovery (effluent from recovery device) for DFM at 5-mm thickness, under 1-ft wave conditions, 60°F water Utility Factor: 0-20% = 0 21-40% = 0.25 41-60% = 0.50 61-80% = 0.75 81-100% = 1.00
10	6	Portability	Transported to spill site in the bed of half-ton pick-up; units handled by two people Utility Factor: Meets requirement = 1 Does not meet requirement = 0
9	7	Maintainability	Detailed cleaning and repair procedures No special tools On-hand stock of spare parts Operator training = 8 hr Manual--detailed, complete

Continued

Table 5. New Skimmer Selection Criteria (Ref 2).

Weight Factor	Rank	Criteria	Standard
			Utility Factor: Meets requirement = 1; Does not meet requirements = 0
9	8	Setup manpower	One person can physically handle each skimmer component (does not include retrieval)
			Utility Factor: Requires three or more people = 0; Requires two people = 0.80; Requires one person = 1.00
5	9	Debris impact	Unit can accept debris of 1/2 in. or smaller and still operate; prevents larger debris from affecting operations
			Utility Factor: Meets requirement = 1; Does not meet requirement = 0
3	10	Storage capacity	250 gal in a separate unit
			Utility Factor: <50 or >500 gal = 0; 50-100 gal = 0.33; 100-199 or 301-500 gal = 0.66; 20C-300 gal = 1.00

Go/No-Go Criteria

There are no weighting factors associated with the Go/No-Go criteria. A skimmer was rejected if it did not satisfy any one of these criteria.

Type of Oil. The skimmer must be able to collect DFM and JP-5 oils from the water surface. Table 2 confirms that 60 percent of Navy oil spills consist of DFM and JP-5; making it essential for the skimmer to be able to recover oil spills of these two types.

Self-Sufficient System. The skimmer must be self-sufficient, including all equipment necessary to collect, store and pump oil, as well as spare parts and operating and maintenance manuals. Spill

response teams will select the skimmer system that is complete and ready to perform.

Operating Manpower. The skimmer must have the flexibility to operate unattended for short periods of time (30 minutes minimum) under Navy standard conditions (5mm of oil in 60°F water with 1-foot harbor chop type waves) at the design oil recovery rate and efficiency. These criteria stem from the users' concerns regarding the reduction of manpower and cost.

Type of Transfer Pump. In order to prevent excessive emulsification of the collected oil, the skimmer system shall use a positive displacement pump to transport the recovered oil-water mixture from the skimmer to the storage system. Emulsification of the oil can lead to problems in separating the oil from the water in a later operation.

Maximum Draft. A large number of Navy oil spills occur near piers and in ditches, ponds, and shore areas with a shallow water depth. A draft of 1 foot is required to enable the activities to recover these spills with the small skimmer.

Ranking Criteria

The ranking criteria can be divided into three categories:

1. Performance Criteria - measures the skimmer efficiency in the environmental conditions under which it is expected to perform its stated objective. The performance criteria included in the evaluation process are the oil recovery efficiency, wave impact, recovery rate, proven equipment, and debris impact.

2. Operation Criteria - based on logistic factors and resources that the skimmer requires to perform its mission including setup manpower requirements, development time, storage capacity and portability.

3. Maintainability Criteria - requirements necessary to operate and maintain the skimmer for mission performance.

The 10 ranking criteria are used to determine an effectiveness index. The effectiveness index is calculated from Equation 1 with the rating factor being replaced by a utility factor. Each ranking criteria has weighting factor that ranges from 3 to 15 paints and a utility factor that ranges from 0 to 1. The maximum effectiveness index value is 100.

The weighting factor represents the relative importance of specific criteria when compared to other criteria. The utility factor represents the importance of the value of a specific criteria based on the users need and available technology. The weighting and utility factors used in the evaluation procedure can be obtained form Table 5. Each of the ranking criteria will now be discussed.

Recovery Rate. The oil recovery rate (ORR) measures the volume of oil recovered per unit time. It is an effective parameter for evaluating the relative performance of skimmers that utilize different oil recovery technologies. The parameters in Table 6 give an indication of the values of the ORR for the different technologies. The ORR is determined by using Equation 2.

$$ORR = \frac{(VO \times PO)}{100 \times (ET - ST)} \qquad (2)$$

where: ORR = oil recovery rate, gal/hr
VO = volume of oil/water mix recovered, gal
PO = percentage of oil in the mix, %
ET = time at end of cleanup or skimmer failure, hr
ST = time at start of cleanup, hr

Table 6. Small Skimmer Performance Parameter Range (Ref 5).

Skimmer Technology	ORE[a] (%)	ORR (gal/hr)
Weir	3.4 - 17.6	36.99 - 142.67
Double weir	1.6 - 45.0	68.67 - 1981.51
Hydroadjustable weir	4.6 29.6	124.17 - 132.10
Oleophilic belt	34.0 - 96.0	211.36 - 528.40
Oleophilic rope or tubing	54.6 - 100.0	71.33 - 713.34
Oleophilic disc	72.0 - 99.0	52.84 - 264.20
Drum skimmers	85.8 - 93.3	84.54 - 89.83

[a]Oil Recovery Efficiency (See definition below).

To minimize the impact on activity operation, the spill should be cleaned up as quickly as possible. For this reason, the ORR is considered to be an important factor in the oil skimmer evaluation. A rate of 120 gal/hr for the ORR was selected as the Navy standard. The Navy standard rate cannot be sustained throughout cleanup operations because of the thinning of the oil slick, but the rate should be met or exceeded in initial operations.

Deployment Time. The time needed to deploy the skimmer impacts the manpower cost associated with the spill cleanup operation. By reducing the deployment time, the cost associated with the recovery of spills can also be reduced. This is especially true of small spills. Typically, the cost of recovery for a 10-gallon spill is $12.50/gallon. For a 150-gallon spill, the cost is $1.65/gallon (Ref 5). The same manpower cost is incurred for skimmer deployment, regardless of the size of the oil spill. Clearly, the deployment manpower cost contributes significantly to the cost cleanup for a small spill. By reducing the skimmer deployment time, the cost of a small spill cleanup will be greatly reduced.

Wave Impact. Wave impact is defined as the wave height under which predicted ORR and Oil Recovery Efficiency (ORE) are achieved (Ref 5). The ORE and ORR reduce significantly with an increase in wave height. Over 30 percent of Navy spills must be cleaned up in at least 1-foot waves with harbor chop (Ref 5). Operator intervention is normally required to maintain the ORE and ORR. Reduction in operator intervention will reduce manpower costs associated with oil spill recovery.

An oil skimmer that is sensitive to wave impact will also require operators with experience to maintain ORR and ORE. Increased training for the operators will be required to achieve the experience needed for proper operation of the skimmer.

Proven Equipment. It was established through interviews with activity personnel that a new skimmer system will not be adopted unless it has been proven to operate more effectively than the existing system (Ref 5). The equipment can be proven by a credible laboratory study and/or reports of actual use.

The types of information to be proven include the manufacturers' stated ORR and ORE, the development procedures, and the maintenance requirements.

Oil Recovery Efficiency. The ORE is defined as the percentage of oil in the recovered mix measured at the storage inlet. The ORE has an effect on how quickly the storage container is filled and consequently how quickly a spill can be collected.

Table 6 gives expected ORE values for the different oil recovery technologies.

Portability. An oil skimmer must be light enough to be handled manually and transported by a standard 1/2-ton pickup for easy and rapid deployment. Access to Navy piers is normally very restricted due to congestion. Similarly, access to remote areas or shoreside at most Naval activities is difficult for large trucks or vans. To ensure rapid response to oil spills, standard pickup trucks are the most effective means of small skimmer transport.

Maintainability. Maintainability is a function of five parameters: easy to clean and repair, no special tools required, easy availability of spare parts, operator training equal to 8 hours due to simplicity of operations, and a detailed operation and maintenance manual. Operation/maintenance should be detailed, easy to understand, and updated whenever necessary.

Skimmers that have minimal maintenance requirements allow more time to be spent on normal activity operations.

Setup Manpower. One of the user goals involves the reduction manpower for skimmer deployment and operation. A reduction in setup manpower will contribute to this requirement.

Debris Impact. The debris impact criterion requires that large pieces of debris not affect skimmer operations. Similarly, the recovered mix pump must accept debris of at least 1/2-inch without

failure. Activities with enclosed harbor or ship repair facilities have a problem with debris affecting spill cleanup. Debris in oil spills that requires cleanup can lead to operating problem with skimmer if the skimmer is not capable of handling debris or if it does not have some form of debris protection.

Storage Capacity. Storage capacity is defined as the total volume of recovered mix that can be stored. The majority of Navy spills are less than 200 gallons in size (Table 2). A design value of 200 gallons could be used for 80 percent of the spills even accounting for recovery efficiencies. The storage unit should be a separate container with 50 to 100 feet of connecting hose. The purpose of the storage system is to hold the recovered oil-water mixture between the time it is recovered and disposed.

Procurement Procedure

A two-step procurement procedure was adopted. In the first step, a procurement package was forwarded to the manufacturers of oil skimmers. The procurement package contained enough information for the manufacturers/suppliers to prepare a technical proposal that provides a product meeting the Navy needs for small oil spill cleanup and recovery. The remainder of the procurement package consisted of a letter explaining the mission, a copy of the procurement criteria, and an evaluation procedure. A copy of the functional and first article test to be performed on the new oil skimmer were also included for reference (Ref 5,12).

The data collection form, included with the procurement package, was used as the basis for the technical proposal. The information on the data collection form was required to accurately and completely analyze and score the technical proposal on a consistent basis. Only the technical proposals with an effectiveness index of more than 75 were chosen for further evaluation.

The second phase of the procurement procedure involved the invitation for bid based on the technical proposals that were acceptable. The lowest bid from the cost proposals was selected as the contractor for the next generation of small oil skimmers. The selected skimmer was subjected to first article and functional tests as discussed in this section.

Development of Reliability, Availability, and Maintainability Calculations Procedures

The acceptance and performance of the new inland oil skimmer was based on two comparisons. First, there was a direct comparison between the old and new oil skimmers on the basis of cost and performance. The second was a comparison of reliability, availability and maintainability (RAM) performance values against past performances for similar equipment.

The baseline for the comparison between the old and the new inland oil skimmers was established by means of an oil skimmer survey. The form for the oil skimmer survey was one of two forms sent with the new

oil skimmer. The evaluation methodology called for cost versus spill volume and manpower versus spill volume to be plotted and the data fitted with a linear regression curve. The results from the existing skimmer equations and the new skimmer equations will be compared to determine the best skimmer system. The data for the new skimmer equation will be obtained from the skimmer usage reports. A plot of manpower versus spill volume and a plot of cost versus spill volume for oil spills recovered at Yokosuka, Japan for FY84 and FY85 is presented in Figures 12 and 13.

The skimmer usage report, to be submitted after each use of the new oil skimmer, will contain the information required to evaluate the skimmer performance. The comparison between old and new skimmers was explained in the previous paragraph. The RAM results will be computed using Equations 3 to 6 and the results compared to industry standards and between activities.

The Reliability of the skimmer is a measure of the probability that the skimmer will perform its mission for the length of the mission time and is calculated using Equation 3.

$$R = e^{-t/MTBF} \tag{3}$$

where: R = reliability expressed as a decimal
e = Naperian base log
t = mission time, hr (Ref 14)
MTBF = mean time between failures, hr (Ref 14)

The Availability of the skimmer is a measure of the probability that the skimmer will be able to perform its mission at any given point in time and is calculated using Equation 4.

$$A = \frac{MTBF}{MTBF + MTTR} \tag{4}$$

where: A = availability expressed as a decimal
MTBF = mean time between failures, hr (Ref 14)
MTTR = mean time to repair, hr (Ref 14)

The Maintainability is a measure of the ease of skimmer maintenance and is calculated from Equations 5 and 6.

$$MTTR = \frac{\Sigma\ (ERT - SRT)}{\Sigma\ NF} \tag{5}$$

where: MTTR = mean time to repair, hr
ERT = time at end of repairs, hr
SRT = time at start of repairs, hr
NF = number of failures

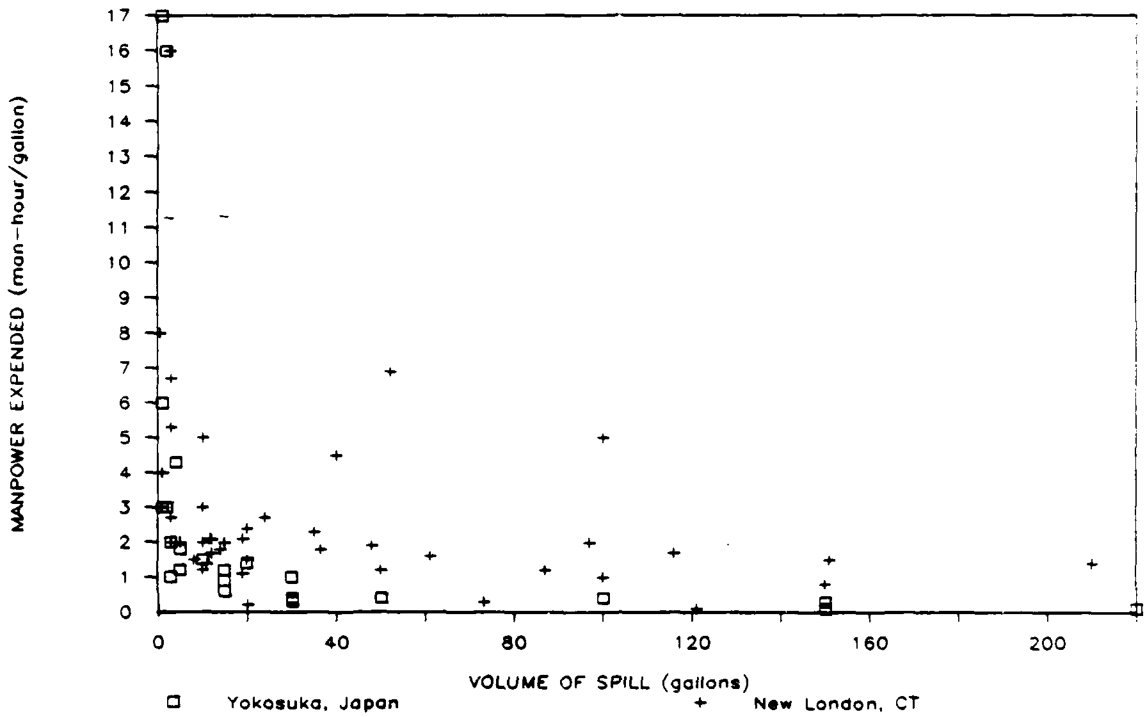

Figure 12. Manpower versus spill volume, Yokusuka, FY84 and FY85 (Ref 13).

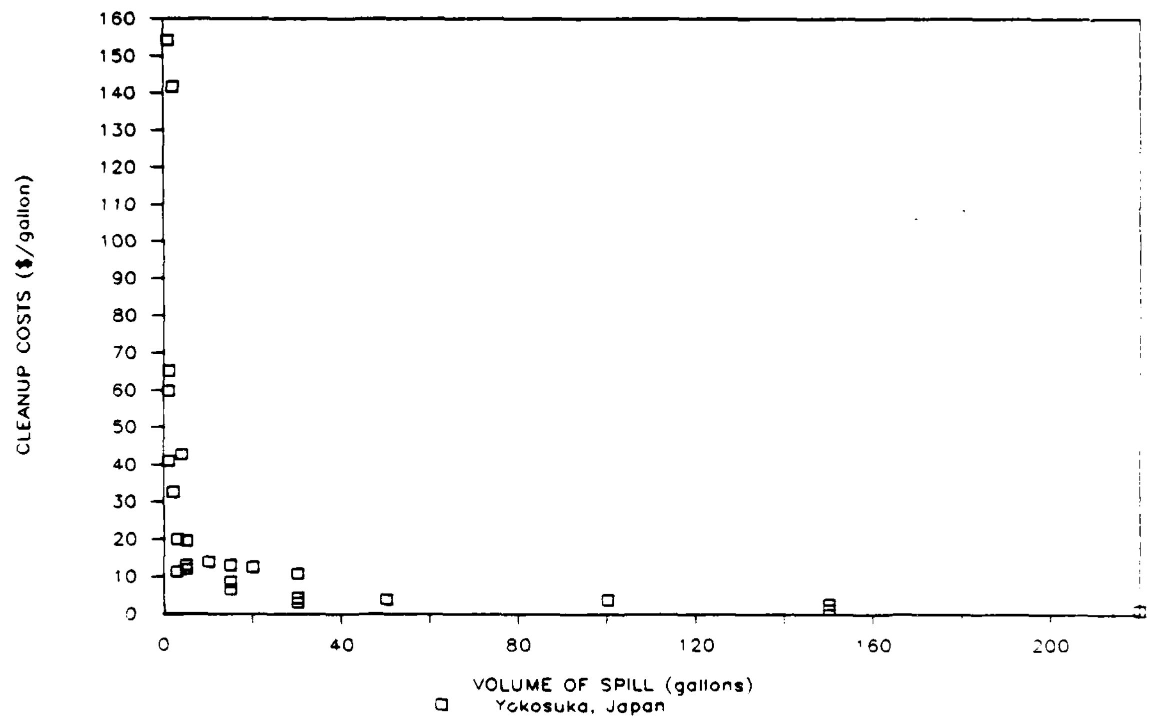

Figure 13. Cost versus spill volume, Yokosuka, FY84 and FY 85 (Ref 13).

$$MI = \frac{\Sigma\ (ERT - SRT) + \Sigma\ (MT + PMT)}{\Sigma\ (ET - ST)} \qquad (6)$$

where: MI = maintainability, expressed as a decimal
ERT = time at end of repairs, hr
SRT = time at start of repairs, hr
MT = length of time required for maintenance, hr
PMT = length of preventative maintenance, hr
ET = time at end of cleanup or skimmer failure, hr
ST = time at start of cleanup, hr

New Inland Oil Skimmer Selection

The new inland oil skimmer selected to meet Navy needs is the Crowley Environmental Alden Industries Model A-4 oil mop type skimmer. The skimmer utilizes two 4-inch-diamter rotating Oleophilic ropes to pick up oil. The ropes are connected to an aluminum frame supported by two 5-foot-long pontoons. Oil is squeezed from the ropes by a set of rollers and pumped to a separate oil storage bag. The ropes and the pump are driven with compressed air obtained from a Energair compressor powered by a Briggs & Stratten gasoline engine or from a compressed air supply of 12 cfm at 100 psi. A photograph of the Crowley/Alden A-4 skimmer is included in Figure 14. A diagram of the skimmer is presented in Figure 15.

When required, the small skimmer was retrieved from its storage location, loaded onto a 1/2-ton pickup truck, and transported to the spill site. At the spill site, the skimmer was deployed by a maximum of two people and left to operate unattended. A flow schematic for the new inland oil skimmer is presented in Figure 16. The skimmer unit should be manually repositioned every 2 to 3 hours and the storage containers emptied. The oil spill should already have been contained by means of booms prior to skimmer deployment.

The specification for the small inland oil skimmer as well as the detailed description of the functional and first article tests (discussed in the next section) are described in the draft specification intended to supersede Military Specification MIL-O-29155(YD), Amendment 1, 17 May 1976. The draft MIL SPEC was developed from experience gained in this study and is included in Appendix C.

Functional Testing of the New Skimmer

A set of seven functional tests were specified by NCEL (Ref 12) to confirm that the new inland oil skimmer is physically completed and meets the physical skimmer criteria. The tests were conducted by the manufacturer at his facilities and overseen by an authorized Government representative.

Confirmation was obtained that all skimmer system components to be supplied with the unit were complete as per the technical proposal. The unit was reassembled without undue force. The unit was continuously operated for 4 hours and it was confirmed that equipment components and the system as a whole operated correctly. The operating and maintenance manuals were checked for completeness. A deployment test run was performed and the time for deployment agreed with the data supplied with the technical proposal. The portability of the unit was confirmed by

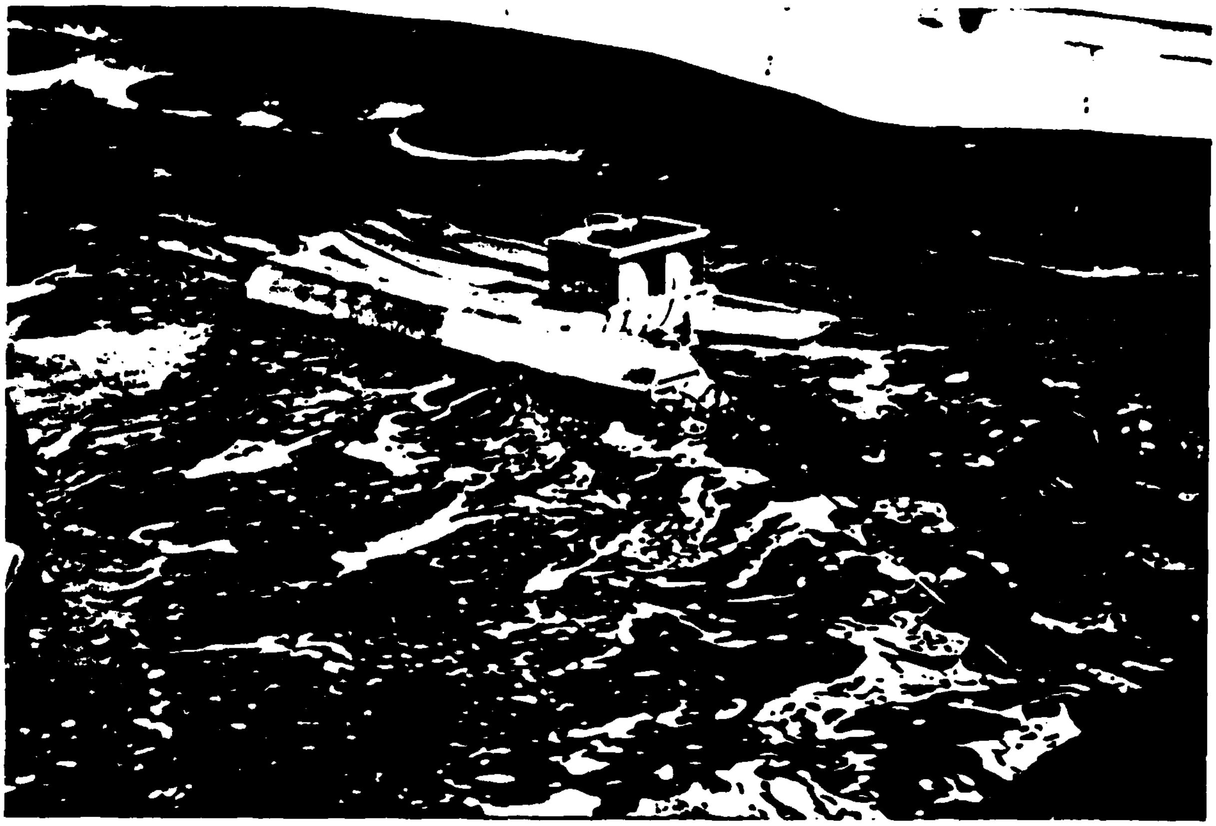

Figure 14. The Crowley/Alden A-4 oil skimmer (Ref 1).

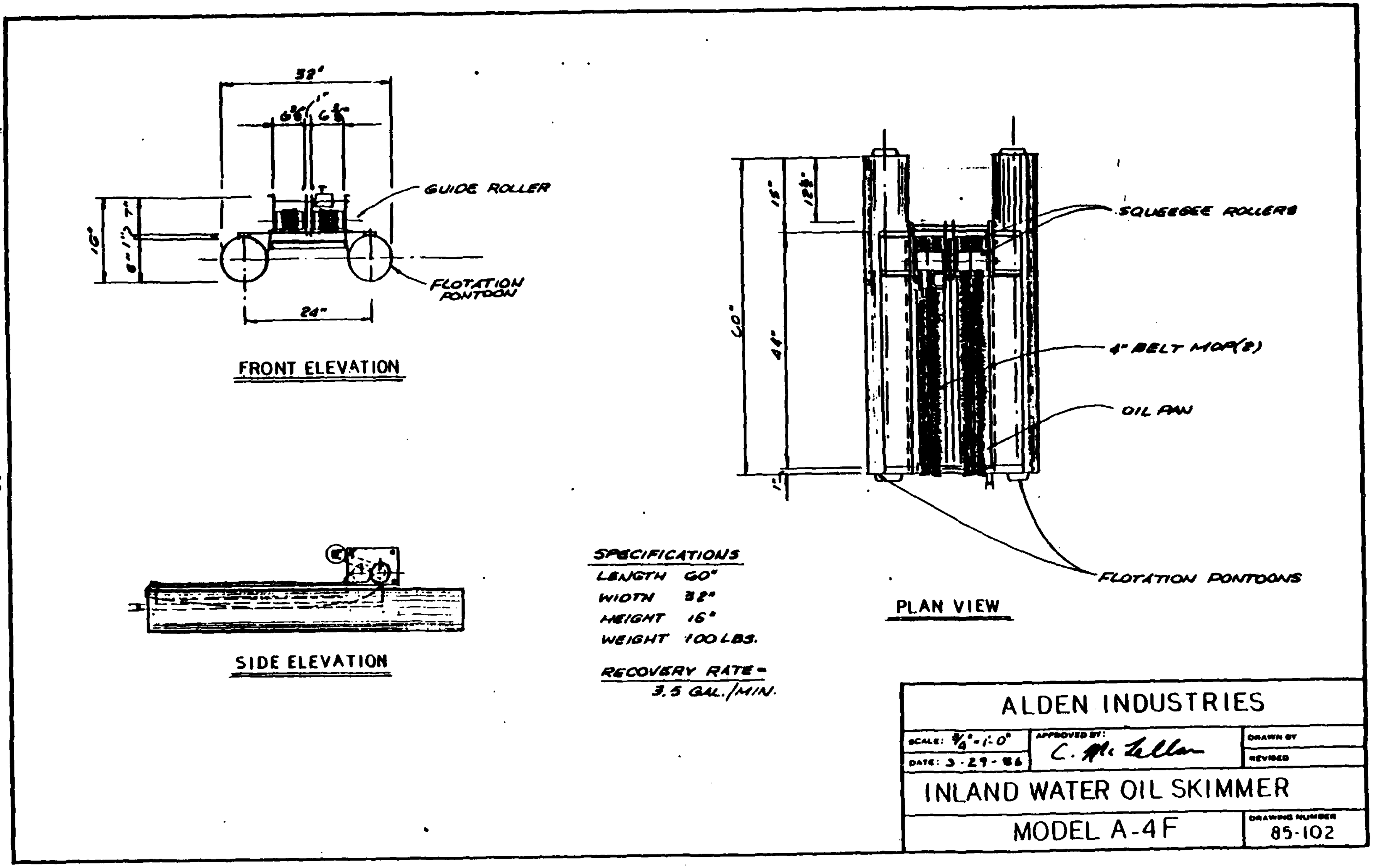

Figure 15. Diagrammatic layout of the Crowley/Alden A-4, oil skimmer (Ref 1).

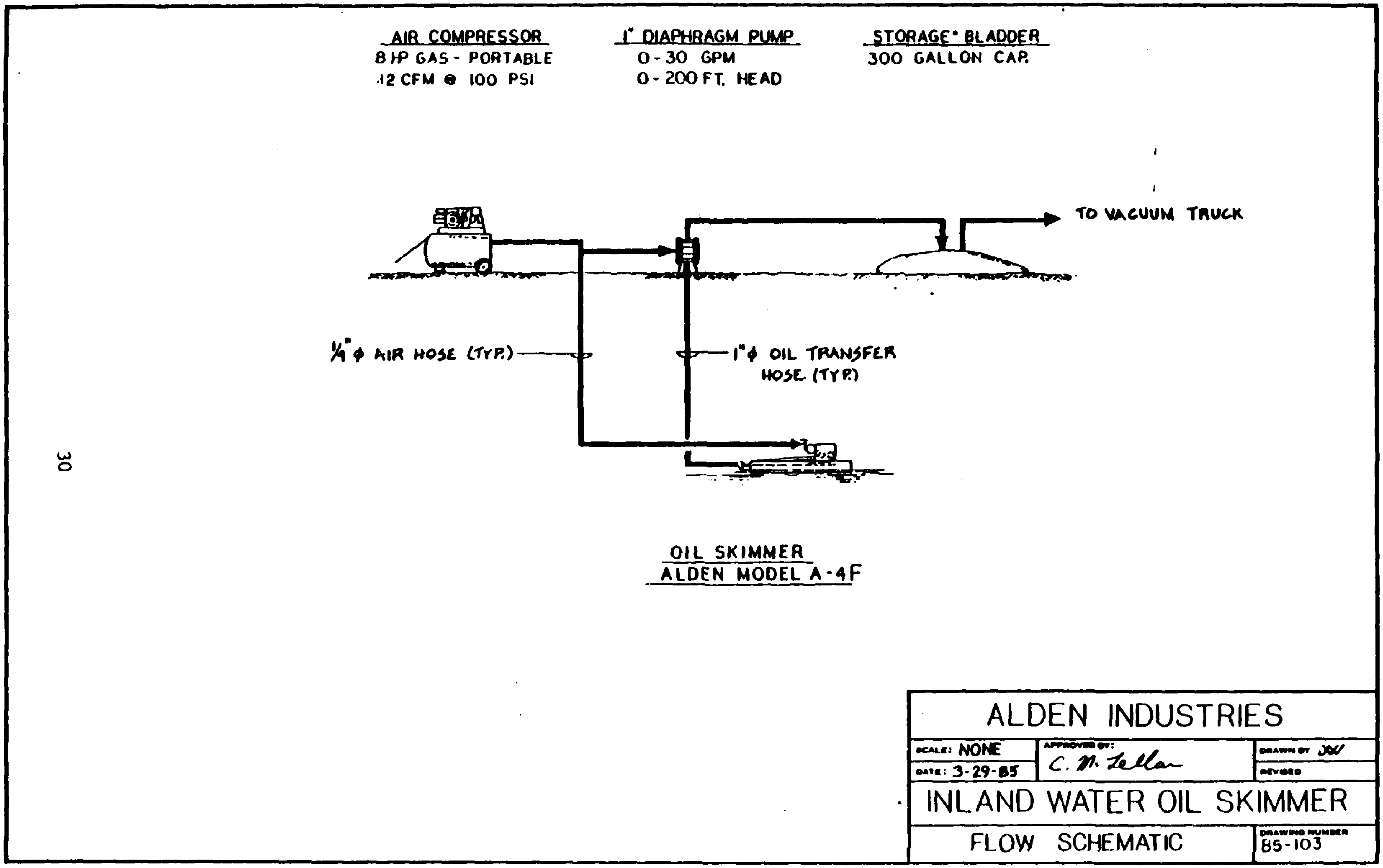

Figure 16. Flow schematic for the Crowley/Alden A-4, oil skimmer (Ref 15).

placing the entire skimmer on the bed of a 1/2-ton pick-up truck. All maintenance steps were performed and it was confirmed that the cleaning and repair procedures were detailed enough and that no special tools were required (Ref 12).

After the satisfactory completion of the functional tests, a unit was shipped for the first article testing.

First Article Testing of the New Skimmer

The first article test performed on the Crowley/Alden A-4 Oil Skimmer at the EPA's OHMSETT facility confirmed that the skimmer met or exceeded the performance characteristics required for inner harbor use (Ref 1). The results of the tests performed at OHMSETT are summarized in Table 7.

Two additional tests not directly associated with oil recovery were performed. The objective of the first test was to determine the pump capacity of the diaphragm pump used for pumping oil from the skimmer to the storage bladder. The test results indicated that the pump will deliver 20 gpm when used with the system compressor (Ref 1). The tests also indicated that approximately 1.1 hours of operation can be expected from the compressor before it needs to be refueled. In the second test, the storage bladder capacity was determined as being in excess of 359 gallons (Ref 1).

Table 7. ALDEN A-4 Skimmer Evaluation Results (Ref 1).

Criteria	Results[a]	
	Desired[b]	Actual
Self-sufficient system	Yes	Yes
Operating manpower	None	None
Recovery rate	120 gph	120 gph
Deployment time	20 min	< 20 min
Wave impact	1 ft/80%	1 ft/70%[c]
Proven equipment	tested	EPA tested
Oil recovery efficiency	80%	65 - 95%
Portability	1/2 ton truck	1/2 ton truck
Maintainability	Easy	Easy
Setup manpower	2 people	2 people
Debris impact	None	None
Storage capacity	200 gal	375 gal
Maximum draft	1 foot	5 inch

[a] Results are for both DFM and JP-5.
[b] Obtained from NCEL Technical Memorandum 54-84-08 (Ref 5).
[c] Average performance was acceptable.

The skimmer collected between 2 to 3 gpm of oil regardless of the test conditions. The recovery efficiency, however, was affected by the waves and dropped from a value in excess of 85 percent in calm conditions to a value above 70 percent in waves.

The skimmer was not affected by floating debris in calm waters. In the unlikely event of debris being splashed onto the belts in waves the wringer/drive can be blocked and jammed. The blockage was simulated by placing sorbent material on the belts near the wringer/drive.

Field Tests of the New Skimmer

After the EPA test, 30 Alden A-4 skimmers were sent into the field to be evaluated under actual conditions. The type of response received from the different activities selected for the field evaluation survey (Ref 13) of the inland oil skimmer are given in Table 8.

Table 8. Results Received from Activities Used in Alden Skimmer Field Tests (Ref 13).

Activity	Oil Skimmer Survey	Skimmer Usage Report	Comment
NAVSUBSUPPFAC New London, CT	X	X	X
USNAVSUPDEP Guam, M.I.	X		
NCBC Gulfport, MS	X		
USNAVSTA Panama Canal, Rodman	X		
FLEACT Yokosuka, JA	X		
NAS Patuxent River, MD	X		
NAVSTA Subic Bay, RP	X		X
USNAVSTA Guantanamo Bay, Cuba			X
NETC Newport, RI			X
NAVSTA Roosevelt Roads, P.R.			X
NSC Oakland, CA			X

The skimmer usage reports returned were not complete; therefore, RAM evaluations could not be conducted. The spill volume versus manpower and spill volume versus cost curves were prepared for the activities that reported the necessary data. Figures 12 and 13 show the curves for Yokosuka, Japan; the only activity for which complete records for the existing oil recovery system were received.

Comments received from the activities contained recommendations on the improvement of the reliability of the skimmer. More durable materials are requested for some parts as frequent breakages of these parts have been experienced. Identification of the types of oils for the which the skimmer can be used was requested. Markings are required on the storage bladder to prevent overfilling during recovery operations.

Most of the activities surveyed mentioned that the packaging of the oil skimmer was poor and that damage to the skimmer resulted. In a couple of instances the Sandpiper diaphragm pump was missing. The general consensus among the activities however was that the new inland oil skimmer should be very suitable for the intended function.

CONCLUSIONS

The Navy has two principle needs in cleaning up small (<200 gallons) oil spills - low manpower requirements and good performance in harbor chop waves. An evaluation was made of a number of different skimmer concepts for cleaning up these small oil spills. Among these concepts, a simple design using polypropylene ropes was chosen as the best method for meeting Navy needs.

The Crowley Environmental - Alden Industries Model A-4 met the Navy requirements by using two polypropylene ropes in a small self-contained unit. Laboratory tests at EPA OHMSETT and field tests at 30 different Navy activities confirmed that the A-4 met Navy requirements under a wide range of conditions.

RECOMMENDATIONS

1. Proceed with the acquisition of the remainder of the new inland oil skimmers incorporating the modifications as suggested by the different activities (Ref 15).

2. Accept the draft military specification as presented in Appendix C as a replacement for MIL-O-29155(YD), Amendment 1, 17 May 1976 (see Appendix C).

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18. Military Specification MIL-O-29155(YD), Amendment 1: Oil Spill Retrieval System, Small Inner Harbor, 17 May 1976.

Appendix A

ACCIDENTAL OIL SPILLS ANNUAL REPORT. NEESA. 1982 TO 1986.

Table 1

OIL SPILLS BY GENERAL LOCATION
FISCAL YEAR 1986

Location	Number of Occurrences	Percent Of Total Occurrences	Total Gallons Spilled	Percent Of Total Spilled	Average Per Occurrence (Gallons)
At Sea	4	1.1	83,510	28.7	20,877
In Port	286	75.9	94,303	32.4	329
Ashore					
Land Contained	66	17.5	104,522	35.9	1,583
Water Polluting	21	5.6	8,421	2.9	401
Total	377	100.00	290,756	100.0	771

Note: At Sea - Spills that occur 12 nautical miles from land and outside the confines of a harbor
In Port - Spills that occur within the confines of a harbor
Ashore - Spills that occur at installations

OIL SPILLS BY GENERAL LOCATION
YEAR 1985

Location	Number of Occurrences	Percent Of Total Occurrences	Total Gallons Spilled	Percent Of Total Spilled	Average Per Occurrence (Gallons)
At Sea	5	1.3	42,795	16.5	8,559
In Port	296	74.0	129,813	50.2	438
Ashore					
Land Contained	55	13.8	61,760	23.9	1,122
Water Polluting	44	11.0	24,236	9.4	550
Total	400	100.00	258,604	100.0	646

Note: At Sea - Spills that occur outside the confines of a harbor
In Port - Spills that occur within the confines of a harbor
Ashore - Spills that occur at installations

OIL SPILLS BY GENERAL LOCATION
YEAR 1984

Location	Number of Occurrences	Percent Of Total Occurrences	Total Gallons Spilled	Percent Of Total Spilled	Average Per Occurrence (Gallons)
At Sea	6	1.4	207,759	45.9	34,626
In Port	338	81.1	104,369	23.1	308
Ashore					
Land Contained	25	6.0	95,423	21.1	3,816
Water Polluting	48	11.5	44,986	9.9	937
Total	417	100.00	452,537	100.0	1,085

Note: * - Less than 0.5%
At Sea - Spills that occur 12 nautical miles from land and outside the confines of a harbor
In Port - Spills that occur within the confines of a harbor
Ashore - Spills that occur at installations

OIL SPILLS BY GENERAL LOCATION
YEAR 1983

Location	Number of Occurrences	Percent Of Total Occurrences	Total Gallons Spilled	Percent Of Total Spilled	Average Per Occurrence (Gallons)
At Sea	8	2.0	5,972	3.0	746
In Port	330	84.0	58,329	26.0	176
Ashore	57	14.0	155,945	71.0	2,735
Total	395	100.00	220,246	100.0	557

Note: * - Less than 0.5%
At Sea - Spills that occur 12 nautical miles from land and outside the confines of a harbor
In Port - Spills that occur within the confines of a harbor
Ashore - Spills that occur at installations

OIL SPILLS BY OIL TYPE
YEAR 1986

Oil Type	Number of Occurrences	Percent Of Total Occurrences	Total Gallons Spilled	Percent Of Total Spilled	Average Per Occurrence (Gallons)
NDF (Naval Distillate Fuel)	141	37.4	142,580	48.9	1,011
NSFO (Navy Special Fuel Oil)	9	2.4	1,864	.6	207
JP Fuels (JP 4 & JP 5)	57	15.1	17,404	6.0	305
Aviation/Automotive Gasoline	8	2.1	7,040	2.4	880
Heating Fuels	12	3.2	9,263	3.2	771
Residual Fuels	9	2.4	8,535	2.9	948
Automotive Diesel	1	*	45	*	45
Lube/Hydraulic Oils	35	9.3	2,023	.7	57
Oil/Water Mixture	45	11.9	79,606	27.4	1,769
Bilge	17	4.5	2,932	1.0	172
Solvents	1	*	5	*	5
Unkown	42	11.1	19,456	6.7	463
Total	377	100.0	290,756	100.0	771

Note: Navy Special Fuel Oil - Includes Bunker C and Bunker Fuels 4,5 & 6, Used Shoreside
Oil/Water Mixture - Mixture of Waste Oils With No Single Type Predominating
Unknown - Oil and Oily Sludges whose Composition Has Not Been Determined
* - Less Than 0.5%

OIL SPILLS BY OIL TYPE
YEAR 1985

Oil Type	Number of Occurrences	Percent Of Total Occurrences	Total Gallons Spilled	Percent Of Total Spilled	Average Per Occurrence (Gallons)
DFM (Diesel Fuel Marine)	160	40.0	151,361	58.5	946
Navy Distillate	3	.8	360	*	120
NSFO (Navy Special Fuel Oil)	13	3.3	15,234	5.9	1,171
JP Fuels (JP 4 & JP 5)	65	16.3	35,331	13.7	543
Aviation/Automotive Gasoline	8	2.0	25,180	9.7	3,147
Heating Fuels	19	4.8	6,465	2.5	340
Residual Fuels	10	2.5	2,690	1.0	269
Automotive Diesel	0	*	0	*	0
Lube/Hydraulic Oils	30	7.5	1,151	*	38
Oil/Water Mixture	56	14.0	14,000	5.4	250
Bilge	16	4.0	322	*	20
Solvents	2	.5	202	*	101
Unknown	18	4.5	6,308	2.4	350
Total	400	100.0	258,604	100.0	646

Note: Navy Special Fuel Oil - Includes Bunker C and Bunker Fuels 4,5 & 6, Used Shoreside
Navy Distillate - Includes Kerosene and Burner Fuels A, 2, & 3
Oil/Water Mixture - Mixture of Waste Oils With No Single Type Predominating
Unknown - Oil and Oily Sludges whose Composition Has Not Been Determined
* - Less Than 0.5%

OIL SPILLS BY OIL TYPE
YEAR 1984

Oil Type	Number of Occurrences	Percent Of Total Occurrences	Total Gallons Spilled	Percent Of Total Spilled	Average Per Occurrence (Gallons)
DFM (Diesel Fuel Marine)	206	49.4	236,165	52.2	1,146
Navy Distillate	2	.5	112	*	56
NSFO (Navy Special Fuel Oil)	16	3.8	38,267	8.5	2,391
JP Fuels (JP 4 & JP 5)	57	13.7	149,244	33.0	2,618
Aviation/Automotive Gasoline	5	1.2	765	*	153
Heating Fuels	4	1.0	860	*	215
Residual Fuels	5	1.2	1,770	*	354
Automotive Diesel	7	1.7	2,779	.6	397
Lube/Hydraulic Oils	25	6.0	4,240	.9	169
Oil/Water Mixture	54	12.9	14,226	3.1	263
Bilge	24	5.3	2,992	.7	124
Solvents	0	*	0	*	0
Unknown	12	2.9	1,117	*	93
Total	417	100.0	452,537	100.0	1,085

Note: Navy Special Fuel Oil - Includes Bunker C and Bunker Fuels 4,5 & 6, Used Shoreside
Navy Distillate - Includes Kerosene and Burner Fuels A, 2, & 3
Oil/Water Mixture - Mixture of Waste Oils With No Single Type Predominating
Unknown - Oil and Oily Sludges whose Composition Has Not Been Determined
* - Less Than 0.5%

OIL SPILLS BY OIL TYPE
YEAR 1983

Oil Type	Number of Occurrences	Percent Of Total Occurrences	Total Gallons Spilled	Percent Of Total Spilled	Average Per Occurrence (Gallons)
DFM (Diesel Fuel Marine)	214	54.0	48,969	22.0	228
Navy Distillate	1	*	100	*	100
NSFO (Navy Special Fuel Oil)	24	6.0	88,999	40.0	3,708
JP Fuels (JP 4 & JP 5)	23	6.0	64,165	29.0	2,789
Aviation/Automotive Gasoline	6	2.0	7,020	3.0	1,170
Heating Fuels	1	*	200	*	200
Residual Fuels	1	*	1,500	1.0	1,500
Automotive Diesel	2	1.0	301	*	150
Lube/Hydraulic Oils	33	8.0	1,541	1.0	46
Oil/Water Mixture	32	8.0	1,818	1.0	56
Bilge	41	10.0	2,419	1.0	59
Solvents	1	*	40	*	40
Unknown	16	4.0	3,174	1.0	198
Total	395	100.0	220,246	100.0	557

Note: Navy Special Fuel Oil - Includes Bunker C and Bunker Fuels 4,5 & 6, Used Shoreside
Navy Distillate - Includes Kerosene and Burner Fuels A, 2, & 3
Oil/Water Mixture - Mixture of Waste Oils With No Single Type Predominating
Unknown - Oil and Oily Sludges whose Composition Has Not Been Determined
* - Less Than 0.5%

SUMMARY BY VOLUME
FISCAL YEAR 1986

Volume Range (Gallons)	Number of Occurrences	Percent Of Total Occurrences	Total Gallons Spilled	Percent Of Total Spilled	Average Per Occurrence (Gallons)
0 - 50	228	60.5	4,845	1.7	21
51 - 100	51	13.5	4,403	1.5	86
101 - 200	30	8.0	5,276	1.8	175
201 - 300	18	4.8	5,050	1.7	280
301 - 400	3	.8	1,200	*	400
401 - 500	13	3.4	6,355	2.2	488
501 - 1000	12	3.2	9,440	3.2	786
1001 - 2000	10	2.7	16,645	5.7	1,664
2001 - 5000	4	1.1	14,600	5.0	3,650
GR Than 5000	8	2.1	222,942	76.7	27,867
Total	377	100.0	290,756	100.0	771

Note: * = Less Than 0.5%

SUMMARY BY VOLUME RANGE
FISCAL YEAR 1985

Volume Range (Gallons)	Number of Occurrences	Percent Of Total Occurrences	Total Gallons Spilled	Percent Of Total Spilled	Average Per Occurrence (Gallons)
0 - 50	240	60.0	4,886	1.9	20
51 - 100	48	12.0	4,203	1.6	87
101 - 200	36	9.0	6,117	2.4	169
201 - 300	22	5.5	5,992	2.3	272
301 - 400	4	1.0	1,460	.6	365
401 - 500	9	2.3	4,290	1.7	476
501 - 1000	12	3.0	9,720	3.8	810
1001 - 2000	11	2.8	17,206	6.7	1,564
2001 - 5000	6	1.5	26,200	10.1	4,366
GR Than 5000	12	3.0	178,530	69.0	14,877
Total	400	100.0	290,756	100.0	646

Note: * = Less Than 0.5%

SUMMARY BY VOLUME RANGE
FISCAL YEAR 1984

Volume Range (Gallons)	Number of Occurrences	Percent Of Total Occurrences	Total Gallons Spilled	Percent Of Total Spilled	Average Per Occurrence (Gallons)
0 - 50	244	58.5	4,702	1.0	19
51 - 100	66	15.8	6,061	1.3	91
101 - 200	29	7.0	4,865	1.1	167
201 - 300	20	4.8	5,550	1.2	277
301 - 400	5	1.2	1,850	*	370
401 - 500	10	2.4	5,000	1.1	500
501 - 1000	16	3.8	13,440	3.0	840
1001 - 2000	6	1.4	8,145	1.8	1,357
2001 - 5000	8	1.9	23,900	5.3	2,987
GR Than 5000	13	3.1	379,024	83.8	29,155
Total	417	100.0	452,537	100.0	1,085

Note: * = Less Than 0.5%

SUMMARY BY VOLUME RANGE
FISCAL YEAR 1983

Volume Range (Gallons)	Number of Occurrences	Percent Of Total Occurrences	Total Gallons Spilled	Percent Of Total Spilled	Average Per Occurrence (Gallons)
0 - 50	250	63.0	5,290	2.0	21
51 - 100	56	14.0	4,843	2.0	86
101 - 200	30	7.0	5,250	2.0	175
201 - 300	10	3.0	2,800	1.0	280
301 - 400	6	2.0	2,291	1.0	381
401 - 500	17	4.0	8,475	4.0	498
501 - 1000	6	2.0	4,349	2.0	724
1001 - 2000	9	2.0	15,920	7.0	1,768
2001 - 5000	7	2.0	21,478	10.0	3,069
GR Than 5000	4	1.0	149,550	68.0	37,387
Total	395	100.0	220,246	100.0	557

Note: * = Less Than 0.5%

Appendix B

MID 1970s SELECTION CRITERIA

(Weights and Scoring Criteria)

Weighted Effectiveness Parameters

	Parameter Weight W		Score S	Weighted Score, W X S	
Oil Collection Performance:	I	II		I	II
a. Completeness of removal	.84	.51			
b. Collected mixture quality	.49	.60			
c. Area coverage rate	.41	.62			
d. Wave sensitivity	.49	.62			
e. Removal rate	.66	.59			
f. Temperature sensitivity	.33	.37			
g. Current limitation	.68	.61			
h. Debris sensitivity	.91	.61			
i. Oil film thickness	.79	.87			
Subtotal:	5.60	5.40			
Operational Efficiency:					
a. Operational Simplicity	.45	.69			
b. Accessibility to small areas	.47	.18			
c. Maneuverability	.42	.45			
d. Transport requirements	.43	.46			
e. Manpower requirements	.23	.36			
f. Personnel safety	.46	.53			
g. Power requirement	.32	.30			
h. Deployment speed	.22	.45			
Subtotal:	3.00	3.40			
Operational Readiness:					
a. Repair frequency	.71	.50			
b. Maintenance time	.30	.41			
c. Cleaning	.39	.29			
Subtotal:	1.40	1.20			
Total Weight:	10.00	10.00			

Scoring Criteria

	0	1	2	3	4
1. Oil Collection Performance:					
a. Completeness of removal: % removed in one pass	<30	30-60	60-80	80-95	>95
b. Collected mixture quality: % of oil	<25	25-50	50-75	75-90	>90
c. Area coverage rate: Sq ft per minute	<200	200-500	500-2,000	2,000-5,000	>5,000
d. Wave sensitivity: Wave height (ft) for 100% increase of water Content in collected mixture	<.5	.5-1	1-2	2-2.5	>2.5
e. Removal rate: gpm of oil	<2.5	2.5-10	10-50	50-100	>100
f. Temperature sensitivity: % change in removal rate from 30°F to 80°F	>50	30-50	15-30	5-15	<5
g. Current limitation: Current (knots) for 100% increase of water content in collected mixture	<.5	.5-1	1-2	2-6	>6
h. Debris sensitivity: Large debris particle (dimension in inches) device can pass without breakdown	1/4	2	4	6	8
i. Oil film thickness sensitivity: % increase of water pickup when thickness changes from 4 mm to 1 mm	200	125	75	45	25
2. Operational Efficiency:					
a. Operational simplicity: Number of manhours of instruction required	>20	12-20	4-12	1-4	<1
b. Accessibility to small areas: Beam width (ft)	>10	8-10	6-8	4-6	<4
c. Maneuverability: Turning radius (ft)	>30	20-30	10-20	5-10	<5
d. Transport requirements: Smallest transport possible (0) C-5A (1) C-130					

(Continued)

(2) Large helicopter (3) Small helicopter (4) No restriction					
e. Manpower requirement: Number of men required	>10	7-10	4-6	2-3	1
f. Personnel safety: Number of sources of potential hazards that can cause serious injury (A source that can cause injury easily will contribute a numerical value of 1; not so easily 2/3; unlikely but possible, 1/3)	2	1.5	1.0	.5	0
g. Auxiliary power requirements: (0) Complex w/high demand (1) Complex w/low demand (2) High demand (3) Low demand					
h. Deployment speed Speed in Water (knots)	<5	5-15	15-30	30-60	>60

3. Operational Readiness:

a. Manhours required to replace key parts (hrs)	<2	1-1/2 2	1 1-1/2	2-1	<1/4
b. Structural Maintenance requirements (0) monthly, (1) 3 months, (2) 6 months, (3) 12 months, (4) none required.					
c. Cleaning: Time between cleaning (hrs. of operation)	<6	12	18	24	none rqr

Appendix C

DRAFT MILITARY SPECIFICATION OIL SPILL RETRIEVAL SYSTEM, SMALL, INLAND, AND INNER HARBOR

Draft Military Specification Oil Spill Retrieval System, Small, Inland, and Inner Harbor, May 1986, superseding MIL-0-29155(YD), Amendment 1, 17 May 1976.

1.0 SCOPE

This specification covers a system for use in removing oil floating on the surface of inner harbor water (see 6.5).

2.0 APPLICABLE DOCUMENTS

The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

SPECIFICATIONS

FEDERAL

TT-P-320	- Pigment, Aluminum; Powder and Paste for Paint.
TT-T-291	- Thinner-Paint, Volatile Spirits Petroleum Spirits.
TT-V-119	- Varnish, Spar, Phenolic-Resin.
PPP-B-601	- Boxes, Wood, Cleated-Plywood.
PPP-B-636	- Boxes, Shipping, Fiberboard.
PPP-C-843	- Cushioning Material; Cellusosic.
PPP-T-60	- Tape: Packaging, Waterproof.

MILITARY

MIL-P-116	- Preservation-Packaging, Method of.
MIL-P-514	- Plates Identification, Instruction and Marking, Blank.
MIL-E-10062	- Engines: Preparation for Shipment and Storage of.
MIL-C-27487	- Coupling Halves, Quick-Disconnect, Cam-Locking Type.

STANDARD

MILITARY

MIL-STD-129 - Marking for Shipment and Storage.
MIL-STD-130 - Identification Marking of US Military Property.

(Copies of specifications and standards required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.

3.0 REQUIREMENTS

3.1 DESCRIPTION

The oil spill retrieval system shall include one Alden A-4F oil skimmer; a 12 cubic feet per minute (cfm), 100 pounds per square inch (psi) gasoline powered, 8 hp, air compressor; a double diaphragm air powered pump; a pillow type collapsible storage bag; 50 feet of 1/4-inch internal diameter air hose with quick connect fittings; 50 feet of 1-inch oil transfer hose with camback fittings; and all other necessary piping, hose fittings, couplings, valuing, specified repair parts necessary for operation of the system, and weatherproof system storage containers, with capacity to contain all components of the system.

3.2 FIRST ARTICLE

When specified (see 6.2.1), the supplier shall furnish one complete retrieval system for first article inspection. The first article shall be either a preproduction model or an initial production item which conforms to all requirements of this specification. Approval of the first article shall not relieve the supplier of the responsibility to furnish equipment in accordance with the requirements of this specification.

3.2 Test Program

When specified (see 6.2.1), a written article test program shall be submitted as specified (see 4.6.1), prior to scheduling the first article tests (see 6.3 and 6.4).

3.3 MATERIALS

Materials shall be highly resistant to salt water, petroleum products, and weathering. Dissimilar metals having detrimental galvanic

corrosion properties shall not contact each other. Material not definitely specified shall be of the same quality used for this purpose in commercial practice and free form all defects that effect serviceability and appearance of the finished product. All material, after use of oil retrieval, shall be easily cleaned with commercially available detergents and water, without damage to the materials.

3.3.1 Polyester Fabric

Polyester fabric weight shall be 10 ounces per square yard minimum with a minimum breaking strength consistent with the requirements of 3.3.2.

3.3.2 Polyurethane Coated Polyester Fabric

Polyester fabric (see 3.3.1), shall be coated with 100 percent polyurethane. The coated fabric weight shall be 40 ounces per square yard maximum. Coating adhesion shall be 10 pounds per inch minimum. Minimum rated breaking strength shall be 850 pounds per inch warp and 700 pounds per inch fill.

3.4 DESIGN

The system shall be designed primarily for minor spills of 200 gallons or less. The system shall be of relatively small size in order to facilitate operation in restricted and congested areas typically found in, under, and around piers and ship mooring facilities. The system shall fit in the back of a standard Navy 1/2-ton pickup truck (area approximately 4 feet by 8 feet). The system shall be portable so it can be carried by two men from a pickup to the spill. The system shall be fully deployed and operational by these men within 20 minutes from the time of arrival at the spill site. The skimmer system shall be capable of being deployed into the water by these men without any cranes or hoists. The weight of any integral unit of the system shall not exceed 225 pounds.

3.5 SYSTEM PERFORMANCE (See Figure C-1)

Figure C-1 represents the primary operating configuration for the retrieval system. The skimmer device (component A) shall operate in a stationary mode and shall remove oil as the oil is naturally induced toward the skimmer. The suction hose (component B) transports the skimmed high oil content oil/water mixture as it is pulled to the pump (component C). The pump, via discharge hose D, shall discharge the mixture to the pillow tank (component E). The pillow tank shall be off-loaded later at the site, and the oil transferred to an oil reclamation site. The skimmer and the pump shall be powered by the air compressor (component F) through air hoses G and H, respectively.

3.5.1 Skimming Device (component A)

The skimmer device shall be an Alden A-4F skimmer or an equivalent device with similar efficiency, stability, and performance properties which is compatible with all other components and the requirements of the specification. The Alden oil skimmer is a pontoon supported, marine grade aluminum frame using two 9-foot 3-inch oleophilic, rope mops to pick up the oil from the water surface. The oil shall be squeezed from the mop by a set of rollers and collected in a sump. The Alden A-4F skimmer is a high efficiency device typically achieving greater than 80 percent efficiency. The mops and rollers shall be powered by a 0.5-horsepower (hp) air motor which shall be connected to the skimmer.

The air motor shall be a manufacturer's standard, lightweight type. The air motor shall be powered by a maximum of 27-cubic feet per minute (cfm) of air at 80 psi.

3.5.2 Oil Hoses and Couplings (components B and D)

All oil hoses shall be 25-foot lengths of 1-inch inside diameter, lightweight hose of the manufacturer's standard heavy duty oil resistant type. One male and one female cam-locking type, quick-disconnet aluminum coupling conforming to MIL-C-27487 shall be installed on opposite ends of each hose.

3.5.3 Air Powered Double Diaphragm Pump (component C)

The air powered pump shall be a manufacturer's standard, reliable heavy duty type. The pump shall be a 1-inch intake/discharge, double diaphragm type. The pumping rate shall be 0- to 30 gallon per minute with a discharge head of 0-to 200 feet, and a suction head of at least 25 feet. The pump shall remain stable under all pumping conditions if placed on a level surface.

3.5.4 Pillow Type Petroleum Storage Bag (component E)

The required pillow storage bag shall have a minimum 250-gallon and maximum 400 gallon storage capacity. The bag shall be constructed from abrasion resistant polyurethane coated polyester fabric (see 3.3.2). The bag shall have dielectrically heat sealed seams and shall be reinforced, with no less than two extra piles of container material, seemed in place, at all areas where fitting flanges are connected The configuration of the bag shall be roughly rectangular with a fill/empty in one corner and a vent fitting in the center. Both fittings shall be on the top surface. The fill/empty fitting shall be a 1-inch threaded pipe with a 90-degree elbow leading to a manual shutoff valve, and a 1-inch female camlock connector. The manual shutoff valve serves the purpose of preventing oil runout from the bag when the hose is disconnected. The vent fitting shall be a 1/2-inch threaded pipe with a cap that shall be removed during filling/emptying operations. A manufacturer recommended repair kit containing hardware, and a 22 mil thick puncture protection mat of the same fabric as the pillow tank, shall be furnished with each bag.

3.5.5 Air Compressor and Engine (component F)

The air compressor and engine shall be a manufacturer's standard, heavy duty type. The air compressor shall produce 12 cfm at 100 psi. The air compressor will have a manually operated pressure release valve, a high pressure safety release valve, a condensate drain valve, a pressure gage from 0 to 150 psig, and a Y-shaped diverter so that two separate skimmer components can be operated at the same time. The engine shall be a manufacturer's standard type. The engine shall produce 8 HP at 3600 rpm, and shall be gasoline powered and air cooled. The engine fuel tank shall contain enough fuel to operate for 1 hour as a minimum. The compressor/engine shall be mounted on two wheels for easier movement, and shall weigh less than 225 pounds. Further compressor/engine shall be constructed so that it will remain stationary during operations.

3.6 STORAGE AND SHIPPING CONTAINER (component H)

Storage and shipping containers shall be designed to retard structural deterioration which would normally occur when exposed continuously to salt water environment for 10 years on both the inside and outside of the containers. The containers shall not permit the entrance of water when exposed to heavy rains driven by 50 mile per hour winds. The containers shall be of unjointed sheath construction. The containers shall all for drainage of accumulated moisture and ventilation for expanded air. The containers shall be designed to facilitate ease in loading and unloading contents. The containers shall provide for securing of the contents to prevents excessive movement during shipping.

3.6.1 Handling Requirements

The containers shall be provided with:

(a) Four-way fork lifting capability.
(b) Skid mounted on lifting pallet/platform.

3.6.2 Container Strength

The container shall be designed to conform with the following strength requirements.

3.6.2.1 Static Strength. The container shall support, without damage, a top load equal to two like containers, each filled with a retrieval system packed for shipment.

3.6.2.2 Torsional Strength. The container, when fully assembled and containing the skimmer system, shall resist the torsional loads created when the container is balanced on each of its four base corners.

3.6.2.3 Impact Strength. The container, when fully loaded for shipment shall resist, without structural damage, impact loads concurrently applied to each side.

3.6.2.4 Lifting Strength. The container, when loaded for shipment, shall resist, without structural damage, repeated lifting by the fork lift from all four sides of the container base without deterioration of structural strength or visible deformation.

3.7 STANDARD PRODUCT

Except where modified herein, it is intended that the equipment and its component parts shall be regular commercial products of the manufacturer or his suppliers. All parts, components, and assemblies shall be new, unused, and free from defects and imperfections which might affect the serviceability or appearance of the finished product.

3.8 TEMPERATURE

Components of the system shall be able to withstand, without degradation, an ambient temperature range from -20 °F. Materials used shall not exhibit appreciable loss of strength or impact resistance within the same temperature range.

3.9 INTERCHANGEABILITY

All systems furnished under the same contract of the same type and size shall be functionally and dimensionally interchangeable. The requirement includes parts, assemblies, and accessories.

3.10 SUPPORT REQUIREMENTS

3.10.1 Technical Manuals

Technical manuals shall be commercial publications furnished as specified (see 6.3).

3.10.2 Repair and Accessory Parts

Repair and accessory parts shall be furnished with each skimmer system. The repair parts shall consist of those recommended by the manufacturer for 100 hours of continuous operation overseas and shall include, as a minimum, the following item:

Component	Quantity	Item description
Skimmer	1	Rope mop - 9-foot, 3 inch long, 4-inch-diameter.
	1	Plastic air supply hose, 1/4-inch inner diameter, 5-feet long.
Air motor	1	Air filter cartridge

Component	Quantity	Item description
Compressor	1	Air filter cartridge
Storage bay	1	Repair kit
	1	Puncture resistant pad
	1	Double male camlock connector, 1 inch.

3.11 MARKING

All marking shall be in accordance with MIL-STD-130.

3.11.1 Container Markings

The system containers shall be marked with 2-inch letters. The four vertical sides of each container must be marked with the following information:

(a) Oil spill retrieval system.

(b) Contents of box 1:
1 - Alden A-4F
1 - Double diaphragm, air powered pump
1 - 250-gallon oil storage bag
2 - 25-foot, 1-inch oil transfer hoses
1 - set of repair and accessory parts

Contents of box 2:
1 - air compressor and 8 hp engine
2 - 25 foot 1/4-inch air hoses

(c) This side up

3.11.2 Storage Bag Markings

The following information shall be marked on the upper surface of the storage bag in 2-inch letters.

PORTABLE OIL SPILL CLEANUP STORAGE BAG
WILL NOT FLOAT

1-inch letters.

Date of manufacturer ________________________.

Contract No. ________________________________.

Capacity 300 gallons ________________________.

Storage temperature -25 °F to +150 °F.

3.11.3 Identification Plate

Plates shall conform to MIL-P-514, type 1, style 1, composition C. Plates shall be affixed to the system in conspicuous places with brass screws or bolts not less than 1/8 inch in diameter.

3.11.4 Instruction Plates

The system shall be equipped with permanently attached instruction plates suitably located, describing and special or important procedure to be followed in operating and servicing the equipment. Plates shall be of the same material, and attached in the same manner, as the identification plates (see 3.11.3).

3.12 LUBRICATION

Lubrication shall be in accordance with the equipment manufacturer's recommendations. Pressure lubrication shall not damage seals or other parts.

3.13 CONSTRUCTION

The equipment shall be designed and constructed to facilitate field maintenance. All adjustments and replaceable accessories shall be readily accessible. Conditions which can be hazardous to personnel or deleterious to equipment shall not be permitted.

3.14 DISSIMILAR METALS

Intimate contact which can be expected to cause galvanic corrosion shall be avoided. When such contact cannot be avoided, an interposing insulating material shall be provided to minimize the corrosive effect.

3.15 CLEANING, TREATMENT, AND PAINTING

Unless otherwise specified (see 6.2.1), surfaces painted in good commercial practice shall be cleaned, treated, and painted as specified herein. Metal surfaces, not painted, which are exposed to the atmosphere or are otherwise subject to a saltwater corrosive environment shall be protected by an integral corrosion-inhibitive coating or shall be of a salt water corrosion-resistant alloy.

3.15.1 Cleaning

Metal surfaces to be painted shall be cleaned to insure that they are free from all oil, grease, welding slag and spatter; mill scale which can be removed by power wire brushing; and products of corrosion,

dirt, or foreign substances. Wood surfaces to be painted shall be smooth, dry, thoroughly cleaned, and free from any substance that would detract from the ability of the coating system to adhere to the surface.

3.15.2 Treatment

3.15.2.1 Metal. As soon as practicable after cleaning, and before and evidence or rust or other contamination can result, metal surfaces shall be treated with a primer pretreatment coating to increase the adhesion of the coating system.

3.15.2.2 Wood. All wood required in the shipping storage containers shall be treated on both sides as follows: (1) apply two coats of varnish specified in TT-V-119, cut one-to-one with thinner specified in TTT-291, type II, grade A; (2) follow with an application of one coat of uncut varnish specified in TT-V-119; and (3) follow with an application of one coat of one coat of varnish specified in TT-V-119 mixed with aluminum pigment specified in TT-P-320, type II, class 2, at the ratio of 2 pounds of paste to 1 gallon of varnish.

3.15.3 Painting

Metal. For metal surfaces, painting shall consist of at least one coat of rust-inhibiting primer and one coat of finish enamel. The rust-inhibiting primer shall be applied to a clean, dry surface as soon as practicable after cleaning and treating. Painting shall be with manufacturer's current materials according to manufacturer's current processes except that the total dry film thickness shall be not less than 2.5 mils. The paint shall be free from runs, sags, orange peel, or other defects. Color shall be light grey.

3.15.3.2 Wood. Treating of all wood required in this specification as specified in 3.15.2.2 shall preclude painting of the wood.

3.16 WORKMANSHIP

Defective components, parts, and assemblies which have been repaired or modified to overcome deficiencies shall not be furnished.

3.16.1 Aluminum Fabrication

The aluminum used in fabrication shall be free from kinks, sharp bends, and other conditions which would be deleterious to be finished product. Manufacturing processes shall not reduce the strength of the aluminum to a valve less than intended by the design. Manufacturing processes shall be done neatly and accurately. All bands shall be made by controlled means to insure uniformity of size and shape.

3.16.2 Bolted Connections

All bolt holes shall be accurately punched or drilled and shall have the burrs removed. Washers or lockwashers shall be provided. All nuts, bolts, and screws shall be tight.

3.16.3 Riveted Connections

All rivet holes shall be accurately punched or drilled and shall have the burrs removed. Rivets shall completely fill the hole. Rivet heads shall be of an approved shape and shall be concentric with the rivet. The rivet head shall make full contact with the intended surface. The rivet shall be fabricated to develop a joint strength not less than the design value.

3.16.4 Welding

Surfaces to be welded shall be free from foreign matter which would be injurious to the weld. Welding procedures shall be in accordance with a nationally recognized code. Welds shall be of sufficient size and shape to develop the full design strength of the parts connected by the welds. Welds shall transmit imposed stresses without permanent deformation or failure when subjected to proof or service loadings.

3.16.5 Casting

All castings shall be sound and free from patching, misplaced coring, warping, or any other defect which reduces the castings ability to perform its intended function.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

Unless otherwise specified in the contract or purchase order, the supplier is responsible for performing all inspections as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own, or any other suitable facilities, for the performance of the inspection requirements specified herein unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification, where such inspections are deemed necessary, to assure supplies and services conform to prescribed requirements.

4.2 CLASSIFICATION OF INSPECTIONS

The inspection requirements specified herein are classified as follows:

(a) First article inspection (see 4.3).
(b) Quality conformance inspection (see 4.4).

4.3 FIRST ARTICLE INSPECTION

The first article inspection shall be performed on one retrieval system when a first article sample is required (see 3.2). A first arti- not been tested at the Environmental Protection Agency OHMSETT facility in New Jersey. If the proposed skimmer has been evaluated, test results showing acceptable performance shall be submitted in lieu of an actual test so that the first article requirements are satisfied. If the proposed skimmer has not been tested at OHMSETT, the manufacturer shall arrange for the test at this cost, or shall provide documentation proving that equivalency of the proposed skimmer with a tested model. Equivalency shall be based on test results showing acceptable performance (see 4.6.2.4 and 4.6.3.5) or design comparisons showing similar design. The first article inspection shall include the examination of 4.5 and the tests of 4.6. The first article may be a standard production item from the supplier's current inventory provided the retrieval system meets the requirements of the specification and is representative of the design, construction, and manufacturing techniques applicable to the remaining retrieval systems to be furnished under contract.

4.4 QUALITY CONFORMANCE INSPECTION

Quality conformance inspection will be performed on each retrieval system. This inspection shall include the examination of 4.5 and the tests of 4.7.

4.5 EXAMINATION

Each retrieval system shall be examined for compliance with the requirements specified in section 3 of this specification. Any redesign or modification of the supplier's standard product to comply with specified requirements, or any necessary redesign or modification following failure to meet specified requirements, shall receive particular attention for adequacy and suitability. This element of inspection shallencompass all visual examinations and dimensional measurements. Noncompliance with any specified requirements or presence of one or more defects preventing or lessening maximum efficiency shall constitute cause for rejection.

FIST ARTICLE TEST

The first article, when required, shall be subjected to the tests specified in 4.6.2 through 4.6.3.9 as applicable. Failure to pass any phase of the required test shall be cause for the Government to refuse acceptance of all systems until corrective action has been taken. Two sets of tests shall be conducted. The first set shall be functional tests (see 4.6.2) conducted by the contractor at the contractor's facilities in the presence of Government representatives. The second

set of tests shall be a set of performance tests conducted at the EPA OHMSETT facility while in the presence of Government representatives. During or after the performance of any test, evidence of any broken welds, cracks in tank, tubes or hoses, and leakage of liquids shall be cause for rejection. Failure to pass any test shall be cause for rejection until such design changes or modifications have been made to correct the deficiencies. All units design changes or modifications made after inspection shall be considered as new units and shall be inspected and tested as specified herein. Design changes requires to pass any test shall be approved by the Government and incorporated in all units furnished under the same contract.

4.6.1 Preliminary Test Plan

Four weeks prior to the date of the first article test, the contractor shall for approval to the Naval Facilities Engineering Command Code 1122B, 200 Stovall Street, Alexandria, VA 22332 an advanced test plan. The plan shall outline preparations as they will be made for execution of the tests described in section 4.6.2 and 4.6.3. The plan shall confirm and expand on the areas for preparation and identify the procedure for testing each component as specified (see 6.3).

4.6.2 System Functional Tests

Data Requirements The following represents the minimum amount of data required to determine the acceptance of the first article as specified in 4.3.

4.6.2.2 System Functional Tests. To demonstrate that the functional requirements are satisfied, the following tests shall be performed.

4.6.2.2 Equipment Supplied. The manufacturer shall show that all the skimmer system equipment components and parts, spare parts, tools, and manuals as specified in the technical proposal have been supplied with the unit. Anything that is missing shall be replaced.

4.6.2.2.2 Manual Review. The manufacturer shall show that the operation and maintenance manuals are detailed and complete. Any errors or missed steps shall be corrected before the first article tests.

4.6.2.2.3 Portability. The manufacturer shall conduct a test on the portability of the unit by placing the entire skimmer system in the bed of a half-ton pickup truck. The entire skimmer system shall fit in the pickup.

4.6.2.2.4 Equipment Setup. Conduct a timed test for taking skimmer from the half-ton pick-up truck to fully operational status. Measure the length of time and the number of people required for the setup procedure. The measured values shall be not more than 20 minutes, and not more than 2 people.

4.6.2.2.5 Equipment Reliability. The manufacturer shall confirm that each equipment component and the unit as a whole are operating correctly. The manufacturer shall check control systems, operating pressures and temperatures, and check for any unusual problems, such as excessive vibration or equipment jams or failures. The unit shall be continuously operated for 4 without a failure. Any unusual conditions shall be corrected before the performance tests.

The skimmer shall be placed in a small tank of water with sufficient space and depth so that the skimmer will float freely.

4.6.2.3 Component Operational Inspection During the test specified in 4.6.2.5, insp :tior c f certain components of the system, while in operation, shall be ma .. The inspection, as a minimum, shall comprehensively observe the following:

4.6.2.3.1 Leaks. The pump, hoses, separator, connections, and storage bag shall be inspected for leaks. Uncollectible leaking due to fabrication or inferior materials shall constitute failure of the test.

4.6.2.3.1 Valves. The pump and storage bag valves shall be inspected for functional adequacy. Uncollectible leaks, or poor handling features due to design, fabrication, or inferior materials shall constitute failure of the test.

4.6.2.4 Overall Evaluation of System Functional Test Results. The oil retrieval system shall be judged to have failed the functional test if any of the following provisions are met:

(a) Component part or manuals are missing.

(b) Manuals are incomplete or inaccurate.

(c) Skimmer system cannot fit in the bed of a half-ton pickup truck.

(d) System setup requires more than 30 minutes or 2 people.

(c) Equipment fails, jams, overheats, or experiences excessive vibration during the 4-hour test.

4.6.3 Performance Tests

4.6.3.1 Test Site. The performance tests shall be conducted at the EPA OHMSETT facility in Leonardo, New Jersey. The manufacturer shall arrange the test with the OHMSETT personnel.

4.6.3.2 Test Plans. The series of tests in 4.6.3.4.1 through 4.6.3.4.7 shall be completed under a test plan prepared by the OHMSETT personnel. All equipment shall be provided by OHMSETT except for the skimmer system which shall be provided by the manufacturer.

4.6.3.3 Data Requirements. A test report on the skimmer evaluation shall be prepared by OHMSETT personnel. The following represents the minimum amount of data required to determine acceptance of the first article as specified in 4.3.

(a) Storage capacity.

(b) Skimmer draft under fully loaded conditions.

(c) Oil recovery rate (ORR) and oil recovery efficiency (ORE) under calm and wave conditions, and for Diesel Fuel Marine (DFM) and JP-5 jet fuel.

(d) Operation without assistance.

(e) Debris interference.

(f) Pump performance (pumping rate).

4.6.3.4 Performance Tests

4.6.3.4.1 Storage Measurements. It shall be assumed that the storage capacity to be measured is between 200 and 300 gallons and that the dry weight of the skimmer is less than 1 ton.

The liquid storage capacity shall be measured by prefilling a calibrated 500-gallon capacity translucent barrel to contain approximately 400 gallons with water. The storage tank shall be check to be certain that it is dry. The 500-gallon tank shall be drained slowly into the storage tank until the storage tank first begins to overflow. The height of the water remaining in the 500-gallon barrel shall be measured. The volume of water drained from the barrel to the storage tanks shall be determined as:

$$V = CdH$$

where

V = volume in gallons

dH = difference in water level heights in inches

C = tank constant gallons/inch (Determined by adding known volumes of liquid to the tank and measuring change in height)

The estimated measurement error with this technique is ±2.5 gallons.

If the storage tank can be crane lifted, it shall be weighted using a strain link.

The difference in weights shall be used with the specific gravity of the water determined using a hydrometer to calculate the storage capacity. The estimated measurement error with this technique is ±0.5 gallon.

4.6.3.4.2 Draft Measurement. The skimmer shall be pre-marked with painted black stripes 1/2-inch wide so that the bottom of the stipe begins at 1-inch intervals. The skimmer shall be checked to assure that all storage tanks are fully loaded (fuel, hydraulics, recovered fluid, etc.) and craned into the test tank. The draft shall be measured at three points (for, aft, and midship) on both port and starboard sides. The estimated measurement error with this technique is ±0.25 inch.

4.6.3.4.3 Diesel Fuel Recovery With Wave Generation. A triangular area of the test tank with sides 29-foot by 38-foot in the lee of a structure shall be boomed off. The skimmer shall be positioned in the center of the test area with the discharge of the pump routed to collection tanks in the auxiliary bridge. An oil slick averaging 5-mm thick (±0.5-mm) shall be created by pump 253 gallons of DFM into the qater surface. The wave generator shall be operated with 1.5-inch stroke for 15 minutes prior to starting the test. The skimmer shall be operated without an the operator in attendance for 1 hour. Oil shall be added as necessary to maintain the slick. The oil shall be added at either 2.5 gpm or at such a rate as claimed by the manufacturer for the ORR. The skimmer discharge shall be routed to alternating barrels at 10-minute intervals. The barrel not in use shall be measured, sampled, and drained prior to completing the pumping to the second barrel. Differences in oil distribution rate oil recovery rate be used to compute changes in oil slick thickness over the test duration. This test shall be repeated three times designated as tests 3R1, 3R2, and 3R3, respectively.

4.6.3.4.4 Diesel Fuel Recovery Without Wave Generation. The four tests executed as 4.6.3.4.3 shall be run without wave generation. The oil shall be replaced at the start of these tests.

4.6.3.4.5 JP-5 Fuel Recovery Without Wave Generation. The four tests executed as 4.6.3.4.4 shall be repeated using JP-5 as the test oil.

4.6.3.4.6 Debris Test. This test shall be conducted with the conditions of 4.6.3.4.4. Debris shall be added to the oil slick near the skimmer. There shall be no repetition.

4.6.3.4.7 Pump Test. It is assumed that there shall be a diaphragm pump as part of the skimmer with a nominal capacity of 2.5 gpm. The pump shall be tested with three fluids (water, JP-5, and DFM). It shall be tested with a negligible discharge head and with the end of the discharge hose at least 15 feet higher than the pump.

4.6.3.5 Overall Evaluation of System Performance Test Results. The oil retrieval system shall be judge to have failed the first article test if any of the following provisions are met:

(a) Storage capacity less than 250 gallons greater than 400 gallons.

(b) Skimmer draft greater than 1 foot.

(c) Average ORR less than 50 gallons per hour under worst wave conditions.

(d) Average ORE less than 70 percent under 1-foot wave conditions.

(e) Skimmer requires continuous attendance to maintain performance.

(f) Debris interfaces with performance.

(g) Pumping rate less than 100 gallons per hour.

4.7 QUALITY CONFORMANCE TEST

All components, subassemblies, parts, and accessories used in the system shall have been inspected, tested, and accepted in accordance with the manufacturer's quality assurance procedures. Each complete production system shall be functionally tested for proper operations and fit of all moving and assembled parts. Every pump unit shall be operated continuously for at least 15 minutes while pumping water at full rated pressures. All floating components and vessels shall be tested for buoyancy and absence of leaks. Storage bag filling shall not be required in this test. Failure of any system, accessory, or attachment to pass all applicable tests shall be cause for rejection.

4.8 PREPARATION FOR DELIVERY INSPECTION

The preservation, packaging, and marking of the retrieval system shall be inspected to verify conformance to the requirements of section 5.

5.0 PREPARATION FOR DELIVERY

5.1 PRESERVATION AND PACKAGING

The preservation and packaging shall be C, as specified (see 5.1.2).

5.1.1 Level A

5.1.1. **Disassembly**. Disassembly shall be the minimum necessary to safeguard parts known to be subject to damage or loss and to accomplish reduction in cube. Bolts, nuts, screws, pins, and washers removed shall be reinstalled in one of the mating parts and secured to prevent their loss.

5.1.1.2 **Preservatives**. Preservatives shall conform to the applicable specifications listed in and shall be applied in accordance with MIL-P-116.

5.1.1.3 Unpainted Surfaces. Unpainted exterior ferrous metal surfaces on the components of the retrieval system, including threaded surfaces and surfaces exposed by disassembly, shall be coated with type P-1 preservative.

5.1.1.4 Engine. Engine, component parts, and accessories shall be preserved in accordance with MIL-E-10062, level A, type II, method I.

5.1.1.5 Pump. The interior surfaces of the pump shall be coated with type P-3 preservative in a manner to insure thorough coating of all interior parts and surfaces. All openings shall be sealed with metal or plastic caps or plugs or tape conforming to PPP-T-60, type IV.

5.1.1.6 Hoses. The hoses shall be coiled to a minimum safe diameter and the coil secured with at least four ties of bottom tape or board.

5.1.1.7 Pillow Storage Bag. The bag fittings shall be covered with cushioning material conforming to PPP-C-843, type I, class A, secured in place with tape conforming to PPP-T-60, type IV. The bag shall be completely collapsed, then folded or rolled to a size suitable for placing in the storage container.

5.1.1.9 Technical Publications. Technical publications, when required by the contract, for each retrieval system shall be preserved in accordance with MIL-P-116, method IC-3.

5.1.1.10 Repair Parts. Repair parts shall be preserved and packaged in accordance with MIL-P-116.

5.1.1.11 Consolidated Packaging. The repair parts and technical publications shall be packaged in boxes conforming to PPP-B-601, domestic type or PPP-B-636, class weather-resistant. The content shall be cushioned, blocked, and braced to prevent movement inside the container or damaging of contents.

5.1.2 Level C

The complete retrieval system shall be preserved and packaged in a manner that will insure adequate protection against deterioration and damage during shipment. This level may conform to the supplier's commercial practice when such meets the requirements of this level.

5.2 PACKING

The following constitutes the total requirements for all levels (A, B, or C). The complete retrieval system shall be packed in the storage container movement and damage to the contents. The lid of the container shall be closed and secured with the fastening devices provided.

5.3 MARKING

Interior packages and storage containers shall be marked in accordance with MIL-STD-129.

6.0 NOTES

6.1 INTENDED USE

The retrieval system covered by this specification is to be used to control oil and debris pollution in inner and outer harbors and inland waterways at various Naval installations.

6.2 ORDERING DATA

Procurement documents should specify the following Procurement Requirements:

(a) Title, number, and date of this specification.

(b) When first article is required for inspection and approval (see 3.2, 4.3, and 6.4).

(c) When test program is required if necessary (see 3.2.1 and 4.6.1).

(d) The requirements for submission of a test program (see 3.2.1, and 4.6, and 6.3).

(e) When cleaning, treatment, and painting are to be other than as specified in 3.15.

(f) Level of preservation-packaging required (see 5.1).

6.3 CONTRACT DATA REQUIREMENTS

When this specification is used in a procurement which incorporates a DD Form 1423 and invokes the provisions of paragraph 7-104.9 (n) of the Armed Services Procurement Regulations (ASPR), the data requirements identified below will be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the contract requirements. Deliverable data required by this specification is cited in the following paragraph:

Paragraph	Data Requirement	Applicable DD 1664
3.2.1	Program, Test	UDI-A-24033
3.10.1	Publications, Commercial	UDI-H-24010

(Copies of Data Item Description required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

6.4 FIRST ARTICLE

When a first article is required, it shall be tested and approved under the appropriate provisions of paragraph 7-104.55 of the ASPR. The first article should be a first production item consisting of one complete retrieval system. The contracting officer should include specific instructions in all procurement instruments, regarding arrangements for examinations, tests, and approval of the first article.

6.5 BACKGROUND

The oil retrieval system is specified as a stationary type which makes use of a pickup device capable of removing oil within a confined area. The mode of operation of the pickup device is such that it removes a confined oil spill as the oil is induced toward the device. The system shall be small, portable, hand operable, and principally designed for minor spills in congested areas, but may be used on all spills, independent of size. It is required that the system shall be completely self-contained in that all components shall be stored in a furnished, weatherproof storage container, and that the system shall be furnished with all pumps, prime movers, power sources, valuing, coupling, piping, and hose necessary to remove oil from a confined water surface upon its delivery to the spill scene. The system shall be designed to be easily and quickly deployed with a minimum of assembly, labor, and equipment. The system shall be designed for simplicity in order to be operated by relatively untrained personnel and shall be capable of being operated in the configuration depicted in Figure B-1.

6.6 NOTE

The use of the Alden A-4F oil skimmer in this specification is not with the intent to limit any prospective manufacturer's interest in this system. It is included because the Alden A-4F forms the basis of the total system as it is currently designed. Alternative methods, which advances in technology may produce, are encouraged and will be reviewed by the preparing activity for inclusion in the specification as they become available.

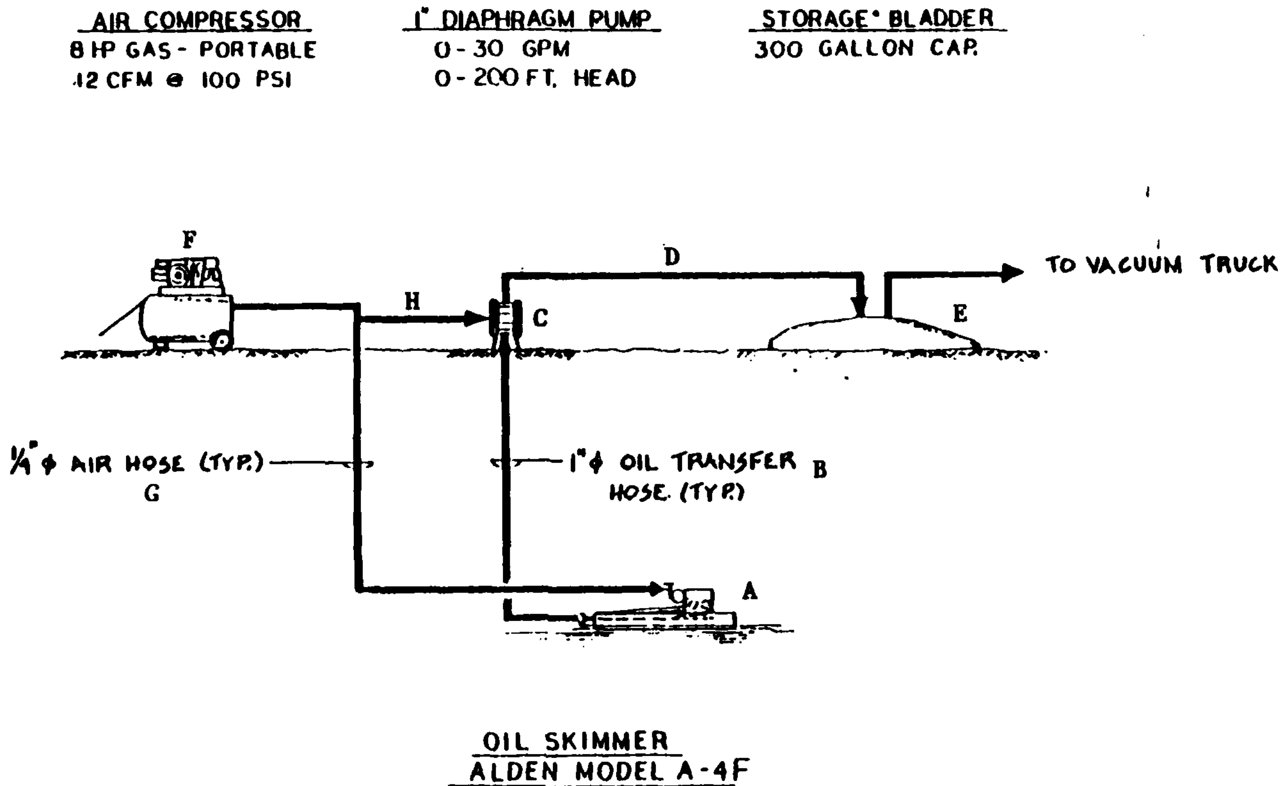

Figure C-1. Operating Configuration for the Crowley/Alden A-4, oil skimmer (Ref 15).

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